DISCOVERY

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Lightning in New York. (See "Photographing Lightning".)

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DISCOVERY

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The Progress of Science

School Biology

"School Biology has been rather naughtily cartooned as an exceedingly complicated ritual worship at the shrine of evolutionary theory, ornamented by a mass of descriptive facts which are claimed to be interesting the more exuberantly, the more bizarre, remote and useless they are." So said F. R. Winton, Professor of Pharmacology, University College, London, in the course of his recent Presidential address to the Science Masters' Association (*School Science Review*, March 1949, 144–50). And despite the 'naughtily cartooned', it is clear that he regards this description as some approach to the truth.

Professor Winton's address is valuable because it will stimulate discussion on the problem of reforming school science courses. First, what is to be the object of school science teaching? Clearly it is not a type of vocational training. For even of those who go to universities only a small fraction continue to study the subject of physics, chemistry, botany and zoology which they learnt at school; the others go into different branches of science, or into such fields as medicine, agricultural science and technology. The object, says Professor Winton, should be first to make boys want to approach suitable problems scientifically, and second to give them some basic equipment for doing so. The mere accumulation of the facts, the jargon or the technical methods of any particular science is of minor importance, though it has hitherto loomed large because it is easy to teach and easy to examine.

But it is not enough to set the target as simply the teaching of scientific method. There is not, Professor Winton points out, any single scientific method, rather there are several different methods, each with its own sphere of validity. The three most important are the *experimental method* ("It is, I believe, exceedingly well taught in physics and chemistry, but astonishingly badly taught in biology"), the *comparative method* (as exemplified by comparative anatomy) and the *statistical method* which is essential to practically all qualitative work in biology and in the social sciences. "If I had to guess," says Professor Winton, "which of these methods would be most useful in tackling the problems that would crop up most frequently in the life of anybody other than a laboratory scientist, I should say that the statistical methods would come first, the experimental methods second, and the comparative methods third." Yet schools teach chiefly the experimental method in physics and chemistry, and the comparative method in biology, while they ignore almost completely the all-important statistical method, which though regrettable is hardly surprising as a high proportion of biology masters were trained before the techniques of R. A. Fisher and others had become firmly established research weapons.

Biology, Professor Winton points out, is probably the most important scientific subject for the average citizen. He then makes the caustic comment with which we opened, and continues: "The morphological aspects of botany and zoology which constitute the major part of school biology clearly provide no sort of introduction to biological methods as a whole, nor are they in themselves facts which need to be remembered later by more than a tiny fraction of the boys." But one cannot design a course to be an introduction to physiology, biochemistry, pathology and a dozen other subjects simultaneously. Selection is necessary, and Professor Winton suggests two principles of selection: first, choose material to illustrate the chief lines of evidence used in the biological sciences; second, choose material which helps to explain the everyday experiences of citizens in the present-day world—transfer the emphasis from the lower and less familiar creatures to man and the aspects of nature that he is most concerned with.

Most biological research workers are concerned with genetical or functional problems. They use mainly statistical and experimental methods, and comparative methods play a minor role in their researches. Yet these last receive most attention in school. Prof. Winton has this to say; "Surely, instead of persisting in this heroic attempt to teach the comparative method, which has few applications and is more suited to post-graduate study, the emphasis of school biology should be shifted to the experimental and statistical methods with their immense contributions to current biological problems in medicine, agriculture and many other fields, including the social sciences."

The trouble is that, while many school masters would agree with the general drift of these proposals, few are equipped to carry them out. Most biology masters are educated directly or indirectly under the influence of the

Honours Schools of Botany and Zoology. But for their mutual convenience university departments are so organised that these particular departments work chiefly in those fields which, according to Professor Winton are wrongly emphasised at school. Research and teaching in human biology and the study of physiology in other mammals is left chiefly to the medical department. And so one could go through the list of subjects or methods whose introduction into school biology is desirable; and one would find that they are chiefly the business of just those university departments which do not normally train school teachers. Furthermore, since school courses are virtually confined to physics, chemistry, botany and zoology, it is the university departments dealing with these four subjects that influence (either through the training of teachers or through examinations) the content of school courses. Departments such as agriculture, medicine and biochemistry, which 'consume' students coming from the schools but do not return masters to the schools, have little chance of influencing the school curriculum.

As a step towards overcoming these difficulties, Professor Winton suggests that the Science Masters' Association should set up a joint committee with the Biological Council, together with representatives of medicine and physiology, which should consider means of increasing the emphasis on human and mammalian biology and on the experimental study of function. As a short-term policy this committee should encourage collaboration between physiologists and schoolmasters to devise new experiments and apparatus suitable for use in schools. As a long-term policy they should outline a general degree course in biology (say botany and zoology, with their accessory subjects, physiology and biochemistry) which would train the sort of teachers that are required, and induce the universities to consider it.

That such problems are not confined to biology is shown by recent discussions in the physics department at Cambridge. There is a strong feeling there that the present courses, while well adapted to the production of high power research physicists, are unsuitable for the training of teachers. And proposals have been mooted for the introduction of a less specialised physics course which would contain a larger proportion of what one might call 'everyday physics' and include courses in the history of physics and the social implications of physical science.

Phosphorus, Problem-Child of Neglect

FAR too many people regard phosphorus as a somewhat awkward element connected with old-time matches, twentieth-century bombs, and patent medicines. The truth is that the 'phosphorus cycle' is every bit as important in biological balance sheets as the far better known 'nitrogen cycle', while the problem of phosphorus utilisation must take a top place in any list of the world's most pressing technical problems. It is easy to forget that phosphorus is needed by all living cells and that man needs a daily ration of about 1·5 grams. Years ago a German scientist, Liebreich, coined the aphorism: "Without phosphorus, no thoughts."

Fundamentally it is a problem of the soil and plant-growth, for Nature has arranged that this nutritional need of man is also a vital need of plants. To that extent Nature's arrangements for close economy are admirable. Unfortunately her detailed arrangements for the biochemical circulation of phosphorus are extraordinarily uneconomical and inefficient and as yet little or no progress has been made in improving upon this situation to the advantage of agricultural production. The phosphatic fertiliser, indispensable though it is, is a less efficient device than an open coal fire; less than a fifth of its phosphorus can be assimilated by the crop and the rest is wasted by soil fixation. Though the problem is world-wide, it presses particularly severely upon post-war Britain. As expressed earlier this year by E. P. Hudson, F.R.S.E., "This country of ours, a small land area with fifty millions of people, has to import indefinitely a lot of phosphorus, and as compared with days gone by much more of that phosphorus has to be in the form of fertiliser phosphorus and relatively less in the form of imported human foods and animal feeds."

It is a problem of availability or assimilation far more than a problem of supply. There is no shortage of mineral phosphate. A number of deposits exist and from time to time new ones are discovered; it would certainly be unduly pessimistic to calculate when the world's reserves of phosphate rock are likely to run out. Indeed, ignore the factor of availability and most soils, as Sir Daniel Hall pointed out forty years ago, contain enough phosphorus to grow at least a hundred crops. But only trifling proportions of the soil's contents are available to plants at any one time and the equilibrium between available and unavailable phosphorus is heavily loaded in favour of unavailability. Additions of phosphorus in available forms to most soils increase their cropping capacities and in some cases make reasonable cropping possible where it could not otherwise be expected.

The crude mineral phosphates are not composed of simple insoluble calcium phosphate. They are complex phosphates, and, although they are of animal origin, fluorine (as fluorides) has been brought into their composition through geochemical processes. In their natural condition they are not readily soluble and hence are not satisfactory plant foods, though some grades of mineral phosphate, when very finely ground, are successful as *slow* fertilisers for grassland. To convert these minerals into fertilisers which are fairly active, a treatment which breaks up the molecular complexity and removes the fluorine seems to be necessary. The principal method—treatment with sulphuric acid to produce superphosphate—is now more than a century old. The idea behind this process was simple enough. Soluble acid phosphates of calcium would be produced and these could therefore enter the soil solution rapidly. In practice, however, the action of superphosphate is not so easily explained. Free lime or magnesia in the soil must quickly precipitate insoluble phosphates; or, in acid soils, the iron and aluminium cations in the soil solutions, must bring about precipitation of the very insoluble iron and aluminium phosphates. In short, a soluble phosphate can have only a short life even in the best of soils. Nevertheless, superphosphate is an effective fertiliser, quick in action and, except on acid soils, exceptionally reliable.

But no amount of discussion can obscure the disturbing fact that out of 100 lb. of phosphorus added to the soil, only about 20 lb. at the most pass into the plant.

Unless a better method of making mineral phosphate available is discovered, the superphosphate industry is not

only indispensable but it must continue to expand. The whole problem has been intensified since the war by the shortage of sulphur and sulphuric acid. Before the war most countries had surpluses of sulphuric acid and superphosphate was a convenient vehicle for its disposal. Today this situation is inverted and sulphuric acid supply is a seriously limiting factor for superphosphate production. This is particularly the case in Britain. When earlier this year the British fertiliser industry decided to proceed with the formation of a research association, it was made clear that the priority item in any research programme would be to improve upon, or find an alternative for, the superphosphate process.

There are some indications that alternative processes might be found. Fusion of mineral phosphates with soda-ash or silica has already produced fertilisers which have claimed efficiencies equal to that of superphosphate. 'Silico-phosphate' was produced during the war by an experimental fusion process in Kent, and a similar fertiliser is being regularly manufactured in East Africa. There is no evidence, however, that these products are more efficient in the soil than superphosphate though their processes certainly obviate the use of acid. Some small-scale research has shown that defluorinated phosphate rock is quite as quick and efficient as superphosphate for vegetable crops. There are some who think that it is possible that the problem can be reduced to one of removing fluorine from the mineral phosphates and that phosphate availability has little connexion with solubility. One thing is certain—the phosphorus problem has been ignored for many years, and the mere fact that a solution is now urgently needed will not make it any less formidable. Whoever solves it will transform the fertiliser industry.

Pilots' Mistakes

DURING the war, workers at the Cambridge Psychological Laboratory carried out a very thorough investigation of the errors made by pilots in flying and of their causes, the results of which have now been published.* The apparatus used for most of the work was a cockpit equipped with controls and instruments, interconnected in such a way that the instruments responded realistically to movement of the controls. The tests, to which large numbers of pilots were submitted, consisted of various forms of exercises in instrument flying; and the apparatus was arranged to record the degree to which pilots responded correctly to the demands set them by the situation.

At the beginning of the investigation, the experimenters had expected that fatigue would prove to be a major factor in causing error, so that errors would normally increase steadily with the passing of time. But the first series of experiments showed that this hypothesis was not valid, for in the case of side-slip the errors increased rapidly quite early in the test and after that only a slight further deterioration took place. Furthermore, a more detailed analysis and some further experiments showed that over the whole period quite complex changes were taking place in the nature of errors—the number of small errors rose to a maximum in the middle of the test and later declined sharply; the number of large errors increased only in the second half of the test; on the whole the *number* of errors increased in the first half of the test and decreased significantly later, but the *size* of errrors only began to increase while their number was falling.

All this suggested that the errors in the two halves of the test arose from different psychological reactions to the test conditions, and so a further experiment was designed to discover if these different reactions could be distinguished and correlated with the psychological behaviour of the individuals concerned. Of 355 pilots tested, 268 showed no marked deterioration of performance during the test. The rest, it was found, could be classified in terms of their behaviour towards the end of the test into types—the *overactive* and the *inert*. The overactive class consisted of those who tended to correct errors quickly, even precipitously, and by means of large movements of the controls; they frequently over-corrected and had to make a secondary correction. The inert class contained those who, in the later parts of the test, tended to leave errors uncorrected for a comparatively long period and to make the correction by means of small control movement; they also tended to neglect certain parts of their task, for example, to neglect instruments situated at the side of the instrument panel.

It was found, further, that these two types of reaction corresponded to two distinct psychological classes. The overactive subjects "felt excited and under strain, tense and irritable and sometimes frankly anxious. They felt that correction was urgent and made it impatiently." Though the task seemed to be getting more difficult, "they were not discouraged, but keen to improve and continued to try to do the test well". Some of them found it difficult to forget about the test when it was over. They slept badly that night; thoughts of the test kept recurring before they went to sleep and even in dreams. The inert class, on the other hand, after an initial increase in activity, relapsed into a more apathetic state. In the later parts of the test they "reported that their interest had flagged and that their concentration had failed. A feeling of strain had now given way to one of mild boredom, tedium or tiredness." They "gave the impression that they had lowered their standards of performance to a level well within their powers. Errors previously felt as threatening their success no longer disturbed them emotionally and were not corrected."

Other sorts of error were discovered, which space compels us to omit. But on the basis of the above brief sketch it will be clear that no simple explanation of increasing tension in terms of fatigue is tenable. The Cambridge workers therefore proposed the alternative theory that the errors arose from various manifestations of what they called anticipatory tension. This tension, which in its more acute forms is akin to anxiety, is the normal response of a human being to any factors which threaten the fulfilment of a task. Minor degrees of tension undoubtedly help the performance, and success in overcoming the earlier difficulties normally reduces the tension. But if the tension is too great, it impairs skill (as various auxiliary experiments showed). In this case errors of overactivity are made; these increase the danger of failure, which in turn increases the tension, so that a vicious circle is set up. That would explain the errors of the overactive class, and this explanation has been well confirmed by further experiments. The suggested explanation of the errors of the inert class, which has not been so well confirmed, is that subjects of this

* *Pilot Error, Some Laboratory Experiments*, by D. Russell Davis (London, H.M. Stationery Office, 1948), 9*d*.

psychological type, having failed to overcome the difficulties, reduce their anticipatory tension by the escapist method of lowering the standard to which they aspire.

These test performances were compared with the follow-up records of pilots, where available. And the results showed that the test conditions were relevant to actual flying. For example, fatal accidents were more than one and a half times more common among the overactive than among the normal subjects and about ten times more common among the inert. Other workers, analysing operational records have demonstrated that in sorties of up to ten hours, errors are not significantly affected by fatigue; while on the other hand errors of computation by navigators have been found to be highest at such times as when crossing well defended areas, when anticipatory tension and other emotional stresses would be greatest.

Several conclusions of practical significance have emerged. Special instructions, explaining to the pilot the errors to which he is most liable, are helpful—they enable the tension to be directed into channels where the effects are beneficial, and they do not (as might have been expected) increase the tension by making the pilot aware of new dangers. In selecting pilots it is less important to assess their aptitude in normal circumstances than to assess the stability of their skill in conditions of stress. The Cambridge Cockpit would provide a way of testing this stability, but it is not convenient for routine use and in any case can only be applied to those with some flying experience. However, some progress has been made towards devising other more convenient tests. To reduce pilot error it is not sufficient to make the material conditions of flight safer; it is more important to make the pilot aware of the improvement, so that adverse anticipatory tension is reduced. Bearing in mind the importance of the emotional factors which have been brought to the fore by the investigation, it is possible to improve training methods so that the tensions are directed into effective channels, instead of leading to frustrations which produce either inertia or overactivity.

Bramah, Brunel and Brinell

AMONG men whose centenaries are commemorated this year these three are worthy of note not merely as machine-makers, but because the history of applied science would be the poorer without their contributions. All of them had the mark of the true investigator in visualising how a scientific principle may be applied to practical use. And yet we have almost forgotten them, forgotten a whole life's work, merely perpetuating their names by virtue of a machine in the case of Bramah and Brinell, or because of an eminent son where Brunel the Elder was concerned.

Joseph Bramah (1749–1814) is associated for all time with the Bramah Press, an invention which brought a revolution to an expanding world of mechanics. Every schoolboy studying elementary science comes across the well-known illustration in his everyday text, a picture of how a small pressure from a piston may yield a steady powerful pressure over a greater area. You may assert that Bramah was fortunate to win a niche so surely established, but that is to forget that the Bramah Press opened up the science of hydraulics, with applications which Bramah himself foresaw in some of his patents. This Yorkshire farmer's son, with little education, was intended to follow the plough—until by one of those lucky accidents he became apprenticed to the village carpenter and set him making machines and tools. He bequeathed to us such diverse benefits as the Bramah fire-engine and the beer-engine and then went on to invent the first ever-sharp pencil, a machine for numbering banknotes, and a pen-making machine for quills which was ousted when the steel nib came along. Only once does Bramah lose marks in today's reassessment. When he made his unpickable lock and wagered £200 on it, he had not counted on the American, Alfred Hobbs, a man who made a kit of special tools for the job and succeeded after 51 hours' effort. One last point on Bramah which rounds off his worth: his training in his works at Pimlico of a generation of British mechanics.

Marc Isambard Brunel (1769–1849) may be compared with Bramah in one or two points. He, too, came from a farm, a farm in Normandy, whence he was banished by unrest in France (another lucky accident) to become a civil engineer and eventually chief engineer to the New York authority. It was a lucky day for this country just 150 years ago when Brunel moved again, this time setting sail for England. A link with Bramah is found with both men calling on Henry Maudslay to help with their schemes, to add practical touches which could mean so much. (The Bramah Press would never have been really watertight but for Maudslay's cup leather, a device pressing against the ram with a positive pressure and subsiding when the pressure was released.) Brunel called in Maudslay when making his machine for producing ships' blocks, an installation at Portsmouth which included forty-three separate machines, yet which enabled ten men to produce as many blocks of superior quality as a hundred did before. Brunel's son has captured the imagination with all he did for railways, with his wide use of cast and wrought iron, then almost a 'new' material, for bridges and for Paddington Station's vast roof. But the father deserves equal commemoration: for machines for casting and for boring cannon; for floating piers and docks seen at Liverpool and elsewhere; for the Thames Tunnel which had to be bricked up for seven years. Yet Brunel refused to give in when inundations threatened ruin to his scheme. His tunnel-shield for protecting workmen was a stroke of genius—called the Teredo, simply because Brunel watched the ship worm, *Teredo navalis*, using its tiny shell as a boring tool, maintaining a closed dry chamber at the head, and lining its tunnel as it went along.

As for Johan August Brinell (1849–1925), born at Bringetofta, Sweden, though one of the leading metallurgists of his time, he 'lives' only in his hardness-testing machine. The average metallurgist of today could recite to you every detail of the Brinell machine which applied a definite load to the metal test piece by means of a hardened steel ball (later replaced by a ball of tungsten carbide), the diameter or depth of the impression being measured to give the Brinell hardness number. But he could probably tell you little of Brinell himself, of the Member of the Swedish Academy honoured with the Bessemer Medal of the Iron and Steel Institute and with other prizes. Perhaps, as regards recognition, Brinell was unfortunate to die in the same week as Queen Alexandra; as a result *The Times* spared no space for an obituary notice for this man of Sweden whose work had attracted so much attention in other countries. On his centenary let us remember that he won high esteem outside Sweden, as well as at home, where he excelled as designer in iron and steel works, then as leader in the studying of North Swedish iron ores, and as pioneer in electrical smelting. He established essential principles of the treatment and qualities of steels, while in 1885 came his classic treatment of the heating and cooling effects on the 'texture' of steel, together with the first fixing of a critical point for steel. At the World's Exhibition in Paris in 1900, there was 'a considerable sensation' caused by Brinell's results from studies of the heating, cooling, chemical composition and hardening of steels.

M. SCHOFIELD

Appleton: Scientist and Administrator

To be Principal and Vice-Chancellor of Edinburgh University is no light task by academic standards; yet to Sir Edward Appleton it must savour of a rest cure, relatively speaking, after the ten strenuous years he has spent as administrative head of the D.S.I.R.

He joined that department in 1939. He was fourth in the line of directorial succession; his predecessors—Sir Frank Heath, Sir Henry Tizard and Sir Frank Smith—were all great administrators, but it remained to Appleton to prove that a research worker of Nobel-Prize calibre may also have the administrative capacity required for the direction of the greatest single Government scientific organisation in Britain. Appleton proved this beyond a doubt.

It is today impossible to say which was his greater contribution to science—his fundamental work on the reflection of radio waves by the ionosphere, or his administrative work in the D.S.I.R.

He was born in 1892, and educated at Hanson School and St. John's College, Cambridge. He gained a First-Class Natural Science Tripos and a Hutchinson Research Studentship immediately before the first World War. He joined up, eventually becoming a wireless officer in the Signals Section of the Royal Engineers. The stocky young Yorkshireman quickly became interested in the practical aspects of the propagation of wireless waves, and his work in this field was, in due course, to lead to the formulation of principles and techniques essentially similar to those on which many radar devices were to depend.

At the end of the war he joined Sir J. J. Thomson's teaching staff at the Cavendish Laboratory, Cambridge, and began his investigations to explain the then puzzling phenomena of radio-signal fading. Balfour Stewart, in the nineteenth century, had suggested the possible existence of electric currents in the upper atmosphere, while Heaviside in Britain and Kennelly in the U.S.A. had independently suggested the existence of a reflecting layer. Herein, it seemed to Appleton, lay the key to the problem.

He placed his ideas before the Radio Research Board, who immediately recommended that facilities and finance be provided for his proposed work. These were given by the Department of Scientific and Industrial Research (D.S.I.R.), and so began his association with the Department, which has continued ever since. Without this early fundamental work of Appleton's, as Sir Robert Watson-Watt has said, "radar would have come too late to have any decisive influence in the war". At about the same time he announced his ideas, Appleton, at the age of thirty-two, was appointed Wheatstone Professor of Experimental Physics, King's College, London.

The existence of the Heaviside-Kennelly layer was proved, when, at 12.15 a.m., December 11, 1924, Appleton, using the B.B.C. Bournemouth transmitter and a receiving station at Oxford, sent out his signals. These, he discovered, were reflected back from the upper atmosphere by a layer 60 miles up. And the reflecting property of radio waves—the principle of radar—was established. Later, using wavelengths between 10 and 50 metres, he penetrated the Heaviside Layer and proved the existence of another layer, 120 miles up—the Appleton Layer. The electrified space between them is the ionosphere. Appleton prefers to call them, however, the 'E' and 'F' layers.

In 1932–3 he led a Radio Research Expedition to Tromso, Norway, to study the effect of the Aurora Borealis on ionospheric reflection. The result led to the discovery of the eleven-year cycle of sunspot activity. There are now forty ionospheric forecasting stations throughout the world. They measure, hourly, the electron densities of the layers, thus enabling short-wave stations to select the most suitable wave bands.

Despite his duties as Secretary of the D.S.I.R., with its fourteen research organisations and its interest in nearly forty co-operative industrial research associations, he managed to snatch some time for research, which includes the study of the radio reflection of meteorites, and has led to the discovery, with Dr. J. S. Hey, that sunspots are powerful emitters of 5-metre radio waves.

In 1947, Appleton was awarded the Nobel Prize for Physics in recognition of his great fundamental work, without which world radio-communications would not be as we now know them. For his early work on radar and his services in promoting Anglo-American scientific collaboration during the second World War, he received the U.S. Medal of Merit in 1947. He has been a Fellow of the Royal Society since 1927.

He is a tireless protagonist for scientific collaboration, which he regards as the keystone to much of his own success, and a keen advocate of the comprehensive application of science by industry. Indeed, the very nature of his researches calls for a capable, organising mind. He does not hesitate to remind industrialists and scientists about the importance of the men in the team and what the supervisor owes to his assistants.

A remark of his on planning is worthy of quotation here. Addressing the Federation of British Industries (at the meeting organised to honour Appleton and Sir Robert Robinson as Nobel Prize-winners) he said: "In all our actions (i.e. D.S.I.R. actions) we have recognised that while it is impossible to plan discovery, it is quite possible to plan *for* it." Everyone with administrative experience will admit the truth of another of Appleton's shrewd remarks—that "It is possible to get almost anything done, if one is prepared *not* to claim credit for it."

His broad approach to science and its problems has urged him to say: "A scientific man should also be the complete 'citizen of the world'. He should not only be fit to live, but also fit to *live with*." He wants complete collaboration between the scientist and the community to decide on the uses of science.

He believes, finally, that "the proper direction of scientific effort and the proper results of such efforts is one of the most important challenges of our time". He is sure, that given the leaders for the many research teams required, the challenge will be met.

I. B. N. Evans.

ARCTIC PROBLEMS OF SURVIVAL

(*Above*) With some 1200 human guinea pigs and 30 scientific observers aboard, the air carrier *Vengeance* noses her way through glistening ice-packs off Greenland. First question the technical experts had to ask was: Can naval vessels stand up to ice? The verdict was that special strengthening of the bows is essential. *Vengeance* herself successfully navigated one ice-field, was holed by a second line of ice.

(*Below*) Immersion is the Arctic's greatest horror. This immersion suit gave complete protection.

SCIENTISTS STUDY THE PROBLEM OF

Living in the Arctic

by DOUGLAS LIVERSIDGE

STEFANSSON's 'friendly Arctic' might one day cease to be friendly: military strategists predict that if a third world war started it would flare across these icy regions.

Arctic training of armed forces is therefore being practised by America and Canada, and recently a Royal Naval task force completed the first British trials—christened Operation 'Rusty'—within the Arctic Circle. This task force included a corps of scientists; for before men could begin to consider fighting an Arctic war they must first conquer a common foe—Nature, in its most extreme moods, with violent winds and great cold, and the horrors of immersion in icy waters. This is where science steps in. From laboratory research designed to augment a close study of Eskimo life and polar exploration, scientists have gained the information enabling them to design clothes and diets for men serving in northern latitudes. Before Operation 'Rusty', many of the prevailing ideas about clothing and feeding were purely theoretical, and a good deal had to be tested in the field; this is particularly true for clothing.

Until comparatively recently, clothing values were assessed mainly by the use of a questionnaire technique. Groups of people, each group clad in a different kit, were questioned on the warmth, 'manœuvrability', and general usefulness of the various garments. This system, however, is too haphazard, depending on the subjective responses of the individual which are notoriously unreliable. For example, a garment—such as the duffle coat—may be popular not because it gives adequate thermal insulation, but because it adheres to an approved fashion.

Fortunately scientists have evolved a method which puts the evaluation of clothing on a more reliable basis. This method, known as the skin-temperature technique, was pioneered by the Canadians and developed by the Americans, notably at the Fatigue Laboratory at Harvard. The British employed it for the first time on the recent Arctic cruise. The aim was to secure measurements of body cooling in relation to clothing and external temperature. In polar areas the wind is a vital factor in this connexion. Reproduction of Arctic conditions in Britain such as would make clothing tests realistic would demand both a cold room (and this would require power to the tune of 1,000 horse-power in order to reach sufficiently low temperatures) and a wind tunnel. Such a project costs around £25,000, and the only place where such equipment exists in Britain is at the Royal Aircraft Establishment at Farnborough. In view of our lack of facilities here in Britain, it was simpler for the naval scientists to carry out their tests on this Arctic expedition.

The physiological tests involved can be carried out in three ways: (*a*) with resistance thermometers; (*b*) with thermo-couples attached to the skin or clothing with adhesive tape, or sewn on to the clothes; and (*c*) with thermo-couples soldered on thin copper discs and held in place by means of a harness.

Leading the Operation 'Rusty' teams were Johannesburg-born Dr. Cyril Wyndham, of the Medical Research Council's Climatic and Operational Efficiency Unit (which is accommodated in the Department of Human Anatomy of Oxford University), and Dr. L. G. G. Pugh, of the Postgraduate Medical School, Hammersmith, who were assisted by Lieutenant-Commander C. R. Cowan, R.C.N., temporarily on the Defence Research Board, Canada, but normally Controller in the Banting-Best Department, Toronto University.

In Wyndham's apparatus a sensitive galvanometer, adapted for use at sea, measured the minute electric forces—in the microvolt range—produced by thermo-couples, one junction of each couple being of Nichrome, the other of Eureka alloy. With the aid of a harness, ten thermo-couples were strapped to various parts of the subject's body. One end of each thermo-couple was kept at 0°C. in melting ice, and the tiny current registered on the galvanometer gave a measure of the temperature (in degrees above freezing-point) of the other end, attached to the body. Thus Wyndham was able to get the temperature of the skin at all ten points. The changes in temperature—as the body gradually cooled or warmed under clothing—was followed for a number of hours, and under ideal conditions it was possible to measure skin temperatures to 0·1°C.

This apparatus, which was built at Oxford, is the standard type employed. Its design is highly suitable because the thermo-couples are small and do not disturb either the clothing or skin; capillary circulation must not be affected by pressure of the thermo-couple against the skin. Moreover, all the wires can be led out of the clothing in the form of a cable to the temperature recording device six yards away.

The aim of Wyndham's experiments were twofold—not only to measure the efficiency of clothing, but to study the responses of the clothed body to cold. The skin temperatures at ten points supplied all the information required. "These points," Wyndham explained to me, "are selected as representative areas of skin. When the temperature at each point is multiplied by a factor, and all ten temperatures are added together, the sum gives a measure of the average temperature of the body's surface. By measuring the mean skin temperature of the body every fifteen minutes over an hour, and by measuring the body temperature in this time, we can tell how much the body is either cooling or heating. We also measure the metabolic rate—the rate at which the body is producing heat. These two measurements provide an index of the insulating efficiency of one set of clothing compared with another, *Insulation* being defined as (*Gradient of temperature between skin and air*) divided by (*Rate of heat production of the body*).

"In this way we compare, objectively, one set of garments against another, and hence measure the real efficiency of their protection against cold."

Wyndham's team tackled another problem—protecting the body's extremities. It is well known that it is more

The scientists who took part in Operation 'Rusty' were particularly concerned with finding out which kind of clothing was best for personnel carrying out a variety of duties under Arctic conditions. The author of our article, who accompanied the expedition as Reuter's special correspondent, acted as a 'guinea pig' in some of the experiments. He is seen here performing one of a series of tests to assess the variation of manipulative ability under different conditions.

difficult to protect hands and feet, because of their shape and because they are working parts. The question arose: if the body is warm do the hands and feet remain warm?—an urgent problem in the case of men doing little work, such as watch-keepers?

To answer this, Wyndham devised a programme in which human 'guinea pigs', exposed to the cold, did little work for one hour, worked fairly hard for a second hour, and again did little work for a third and final hour. This programme was designed to show how quickly the body and skin cooled when comparatively inactive, how quickly the body—especially the hands and feet—warmed during heavy duties, and how rapidly the body, skin, and extremities cooled when little work was done in the last hour.

Wyndham obtained further interesting data from some other exercises. In the first, a crew of six marines and six sailors, wearing sheep-skin coats and other Arctic clothing, were chosen to man a pom-pom gun for four hours. Once every hour they had to train the gun on to a target. The time taken to perform this operation and the accuracy with which it was fulfilled were measured. This study was both filmed and timed by stop-watch.

A comparison of their performance under Arctic conditions and in temperate waters was made.

Back at Oxford, Wyndham is now unravelling results to assess whether extreme cold presents a menace to Arctic operations. This much he already knows: that after arduous duties the body temperature can be not only maintained but increased by vigorous exercise, even when the subject is scantily dressed. He proved this himself. With Mr. W. G. Wilson-Dickson, his technical adviser, he ran a mile over the flight deck of the aircraft carrier *Vengeance* wearing Arctic kit, then a similar distance in nothing more than shorts and vest. Despite intense cold and high wind velocity, the body temperature was increased, and neither runner experienced any serious effects.

Unfortunately, Wyndham's apparatus needs very sensitive galvanometers which are not portable. In contrast, Dr. Pugh's equipment, involving resistance thermometers instead of thermo-couples, was both robust and portable. Used for the first time, the individual thermometers, or applicators, consist of fine glass beads containing a metallic oxide, the resistance of which varies with temperature. The changes in resistance are measured by a Wheatstone bridge with valve amplifications. This apparatus is not influenced by environmental temperature. Ten thermostatic applicators are numbered and, attached to a harness of light plastic material, are strapped to the naked body. You then plug in and read the temperature in degrees on the instrument's dial, also numbered to correspond to the various applicators. The whole of the subject's body temperatures can be read at any time within three minutes.

Individual Variations

This device is the only one of its kind in existence, and this was the first time it had been applied to skin temperature work. Designed by a Brighton firm of instrument makers, Light Laboratories, the recording equipment is used in research on peripheral blood vessels in hospitals. Pugh adapted it for the skin-temperature tests.

Collaborating with Pugh was Mr. Harry Kay, of the Department of Psychology, Cambridge University. Every fifteen minutes Kay subjected the 'guinea pig' to tricky manipulation tests to assess operational efficiency under prolonged exposure.

In general, manipulative ability deteriorates over a period, but tests revealed marked variation among subjects. Some men were able to work without gloves for some while in temperatures well below freezing-point; others almost immediately had numbed hands.

These variations among individuals are a vital observation, and hitherto had not been studied extensively. Much data was accumulated so that it could be checked later in the laboratory.

Pugh's new equipment enabled him to gather a tremendous range of statistics, and certainly assured him that the Arctic clothes—varied for different duties—offered adequate protection. "But," Pugh remarked, "in certain

cases there will have to be adjustments in design to permit greater manœuvrability."

Learning from the Eskimo

The most important clothing kit issued to all the 2,000 human 'guinea pigs' was the British anarak—a version of the suit of the native of the *tundras* and *muskeg*. Since he trekked into the Arctic from Mongolia more than a thousand years ago, the Eskimo has evolved ideal dress made of caribou skin. Scientists have studied his wardrobe carefully; they have learned that the hide has these virtues—it is waterproof, it keeps the body warm, yet it allows perspiration to seep out. The last point is most important; one of the dangers of extreme cold is that during exercise you usually get too hot, and this heat can only be dissipated if the body is able to perspire freely. Unless properly equipped, it would become possible for your underclothes to become saturated with perspiration which could then freeze and so cause death. Eskimo dress, however, is so designed that a current of air passes through the clothes and regulates the temperature; the fur around the hood prevents ice forming around the face, while the fringes at the bottom of coat and trousers serve as a wind break.

To test the insulating value of various types of experimental clothing numerous readings were made of skin temperature. The harness shown here provides a simple means of strapping on the body a set of thermo-couples, which enable the temperature at each of the points on the skin to be measured. Wearing the harness is Lieut.-Commander C. R. Cowan of the Canadian Defence Research Board; on the left is Dr. L. G. C. Pugh of the Postgraduate Medical School, Hammersmith; on the right, Mr. Harry Kay of the Department of Psychology, Cambridge University.

Obviously, if a whole military expedition had to be equipped with caribou-skin clothes, the caribou, on which the Eskimo economy depends, would soon be made extinct. It has been necessary therefore, to find a substitute.

The most fascinating aspect of the British anarak—designed by Surgeon Commander E. W. Bingham, R.N., who has led expeditions to the Arctic and Antarctic—is a remarkable cotton outer covering. This fabric, which is both waterproof and capable of warding off the most vicious winds, comes from the laboratories of the Shirley Institute, the cotton research centre at Manchester. The secret of this light and costly Ventile textile is a subtle intricate weave. Beneath this outer garment is a white jacket, with fur-edged hood, and long, baggy trousers are made of the Shirley Institute textile. This fabric prevents the body from losing its heat. Next to the skin is a string vest which, because of its looseness, holds a layer of insulating air between the skin and the neighbouring clothes. The remainder of the clothing varies according to the men's respective duties. But, generally, fine silk gloves plus felt and leather mittens safeguard the hands; a submarine frock or seaman's jersey affords additional warmth for the body; and a rather delicate black jacket and trousers of nylon protect against lashing rain and turbulent seas. These are a few of the garments available for Arctic warfare; all are the outcome of intensive scientific research aimed at safeguarding men from exposure.

Immersion, of course, is the worst of all the Arctic's horrors. To fall into these waters unprotected would, in most cases, mean death; a man is unconscious within five minutes and dead within twenty.

The first acute pain caused by immersion is followed by a brief period when the victim experiences a pleasant feeling of comfort before lapsing into unconsciousness. But Arctic forces today need have no fear of icy waters. Naval and amphibious troops could be fitted with an inflatable rubber suit that keeps the body afloat (even in rough seas), warm and wholly dry. It is a modification of the R.A.F.'s inflatable suit, but has been improved upon by Surgeon Lieutenant-Commander E. Boyd Martin, director of the Royal Naval Air Medical School at Gosport. Martin has also devised an immersion suit for airmen. It is fitted with a life-saving jacket, and the texture again relies on a subtle cotton weave. The suit has a dual purpose: it keeps the body warm when immersed in water, or when exposed to gales and acute cold on land.

But clothing on its own fails to keep a man warm; adequate food is also imperative. Whether fighting or working, a man must have 4,000 calories of food daily.

Dr. Pugh, who served in the late war with the Snow and Mountain Warfare School in the Lebanon, contends that the increased food allowance was the most important single factor in maintaining morale during Operation 'Rusty'. "You must feed the men adequately," he said, "otherwise they will become hungry and lose interest in their jobs. Another important point: unless the food is palatable men won't eat it when they are tired, and in cold areas their calorie demand increases as the temperature falls."

Men afloat, as during Operation 'Rusty', can usually rely on a diet of meat, fish, and vegetables. But all forces—and especially soldiers and airmen—will, in the event of Arctic warfare, have the benefit of traditional Eskimo foodstuffs. Of these, pemmican—dried lean meat pounded to powder and mixed with fat in a one-to-one ratio—is the most significant. The pemmican that scientists have now evolved—and which was tested on the recent cruise—differs from the original pemmican produced by Stefansson. Nowadays, additional items such as treacle and raisins are included.

There is, however, a limit to the amount of fat a person can consume—normally, this is around 150 grams a day, but in the Arctic people have grown accustomed to eating as much as 300 grams daily. The Eskimo subsists entirely on meat products, and Stefansson, who spent about ten years among Eskimo tribes, claimed that a man could live entirely on meat. To confound scientific critics, on his return, he fed on a rigidly controlled diet in a New York hospital and maintained perfect health. His subsequent book—*Not By Bread Alone*—serves today as a valuable guide to military dieticians.

Eaten down in the warm bowels of a ship, pemmican proves rather unpalatable, however, though Peary was certainly right when he said that, eaten in the open air, "Of all foods, pemmican is the only one a man can eat twice a day for 365 days a year and have the last mouthful taste as good as the first."

The polar native's dietary methods generally are being studied to plan a diet for the polar trooper. But, so far, pemmican has proved to be the most popular for varied use. Impervious to heat, water, or cold, it remains fresh for an indefinite time. It takes up little space. A 100-lb. block measures only 2 ft. by 1 ft. by 6 in., and will provide three good meals for 130 men—at least twice the capability of 100 lb. of K rations.

In the war, pemmican was included in the soldier's diet in certain theatres—but often with disastrous results; it was so dry that men could not get adjusted to it. The new pemmican tested during Operation 'Rusty' has not this disadvantage and has been included in the Arctic airman's emergency kit. Sufficient is carried to sustain a man for six days. This footstuff will be ideal for air crews generally, especially those engaged on high-altitude flying, for it yields little or no gas in the stomach. On the other hand, mixed foods produced expanding gases, which tend to press against the diaphragm and can interfere with the heart.

For polar troops generally, pemmican has the advantage over most other foods in that it reduces bowel frequency to about once weekly—a very useful quality in view of the dangers of frostbite. Scientists have studied pemmican extensively since Operation 'Muskox'—the winter manœuvres held in the Canadian Arctic two years ago.

To guard against serious condensation in the ships—more so in the cabins and mess decks—unique steam heaters were placed at strategic points in the ventilation shafts, but to make the ships habitable meant reducing the flow of air. As a result, an important question had to be answered: would the bacteria population rise to dangerous levels?

To solve the problem Dr. J. E. Lovelock, of the Harvard Hospital, Salisbury, Mr. F. E. Smith, of the Medical Research Council, and Surgeon-Commander M. F. Sheehan, R.N., of the Royal Naval Air Medical School, devoted tedious hours to measuring the bacterial concentration in the air in various parts of the ships and co-related the numbers with the amount of ventilation supplied. At the same time a team of experts from the Directorate of Naval Construction (led by Mr. F. S. Sutherby) studied other habitality factors such as temperature.

Numerous tests showed that aerial bacteria were not a danger. Ten per cent of these bacteria were harmless organisms from the skin, nose, and mouth of the sailors. The remaining 90%, equally harmless, came mostly from clothing—notably blankets.

Lovelock's environmental tests also included measuring the rate of ventilation. This was achieved by releasing a tracer substance—in this case helium—in the various compartments. "It is the only satisfactory way in which we could do this," Lovelock told me. "After the helium is released from a cylinder it gradually disappears as fresh air is introduced by ventilation. By assessing the speed at which it is diluted we can get an index of the rate of ventilation."

ROCKETS IN 1749

On May 4, 1749 there was read in the Royal Society a paper by Mr. Benjamin Robins entitled "Observations on the Height to which Rockets Ascend." Robins was a mathematician of eminence, but is chiefly remembered as one of the founders of the science of ballistics.

He was the inventor of the ballistic pendulum, and using this, and his 'whirling arm' apparatus, he made the first useful experiments on the resistance of the air to projectiles. Previous ballistic work had assumed theoretical laws of resistance, but Robins obtained an empirical law which was some approximation to the truth—among other things he discovered the rapid rise of resistance that takes place when the velocity approaches that of sound.

In the 1749 volume of the *Philosophical Transactions* there is little research, if any, that surpasses Robin's paper, though does not represent his most interesting work. By a simple triangulation method Robins measured the heights reached by rockets from a firework display. He found that most of them rose about 440 yards, while one reached 615 yards—which seems almost trivial to an age that sends rockets into the stratosphere and contemplates the possibility of sending them to the moon.

If there is this quantitative contrast between 1749 and 1949, there is, alas, a too close resemblance in other respects. Robins was interested in rockets because they might be used for "giving signals for naval or military purposes"—the use of rockets as projectiles did not seriously begin until the early nineteenth century, when Sir William Congreve made them into weapons of some importance. But the firework display which Robins used for his measurements was a peace celebration!

Later in the same year Robins proved that rocket signals were visible some fifty miles away. His work seems to have promoted quite a lot of interest, for we find another paper in 1750 by John Elliott, reporting the work of several people who were trying to increase the height. One of these, a Mr. Da Costa, made a rocket which rose to over 1200 yards. To double the maximum height in one year was quite an achievement.

The Foundation of All Wealth

E. M. FRIEDWALD

EVER since Dr. Rostas wrote his first essay on comparative productivity in Britain, Germany and the U.S.A., in the *Economic Journal* of April 1943, public attention has increasingly been centred on the subject of PMH. The reason is obvious: output per man-hour is the foundation of all wealth; and the major problem of post-war Britain is the rebuilding of the wealth destroyed by the war. For wealth, in practice if not in theory, is the essential prerequisite for both Full Employment and Social Security. Nor can the battle-cry "Export or Die" mean anything but the choice between a high output per man-hour and a low standard of wages. For British exports can only be competitive if wages are matched by productivity: high productivity, high wages— low productivity, low wages.

Indeed, productivity is the central problem of Britain's economic and social policy. And anything which throws light on this problem deserves the closest attention, not only of those who direct policy, in the Government or outside it, but of the nation as a whole.

Unfortunately, Dr. Rostas's latest contribution to this subject* is not likely to find its way into the hands of the average Englishman. But this is no reproach to a clear as well as scholarly statistical study of comparative productivity in British and American industry. Dr. Rostas did not set himself the task of stating in popular terms for wide circulation the striking disparity between British and American output per man-hour in industry. But there is no field where the dramatic diffusion of facts and figures could do more to stimulate efforts for Britain's recovery.

For the startling conclusion which emerges from these facts and figures is that, before the war, the output per man-hour in British manufacturing industry was on the average very little more than a third of that of American industry. In certain branches, such as automobiles, rubber tyres and pig iron, the American figure was 4 to 4½ times as high as the British; in others, such as steel and cotton, it was only twice as high; in the case of cement it was only 21% higher. But for manufacturing as a whole, American output per man-hour was 2·8 times as high as the British. In mining it was well over four times as high.

It might then be expected to follow that real income per head should have been correspondingly higher in the U.S.A. than in Britain. Actually, before the war, it was only slightly higher. And one is naturally led to seek the reasons for this discrepancy.

In this connexion, it must first of all be remembered that the working week was longer in Britain than in the U.S.A., so that output *per man*, as contrasted with output *per man-hour*, in the manufacturing industries was only 2·2 times higher in the U.S.A. than in Britain. But this last figure is again considerably reduced if the comparison is extended to include all branches of national economy. It is true that American superiority in output per man was even greater in mining than in manufacturing and was about the same in public utilities as in manufacturing. But it was less marked in services (1·7 times), in distribution (1·5 times) and in building and construction (1·15 times), whilst in agriculture and transport American output per head was roughly equal to the British.

Thus when account is taken of the national economy as a whole, American output per head was only 1·7 times the British.

The next important adjustment to be made is that for the distribution of the working population between the different branches of the national economy. In some of those productivity was higher than in others, and here the U.S.A. was at a disadvantage in having a larger proportion of her working population engaged in the less productive sectors than was the case in Britain. The most striking as well as important instance was provided by agriculture, where the value of the net yearly output per worker in Britain amounted to £159, as against £229 in manufacturing. But in Britain only one-twentieth of the working population was engaged in agriculture, whereas in the U.S.A. the proportion was nearly one-fifth. In other words, Britain's standard of living was raised by the fact that, instead of employing people in agriculture (with a relatively low output per head), she imported the bulk of her food requirements and thus saved her manpower for employment in the industries yielding a higher economic return than agriculture. When account is taken of the distribution of the working populations, American output per head is brought down to 1·5 times the British.

Allowing for the fact that Britain had a larger proportion of working population and a smaller proportion of unemployed than the U.S.A., the figure of 1·5 is still further reduced to 1·24. Lastly, allowing for the higher British income from foreign investments, the final figure emerges as 1·18, which corresponds approximately to the comparative real income per head.

This was the position in the years 1935–39. Since then, however, the trend of events has moved against Britain.

First of all, the overseas investments have, to a large extent, disappeared during the war, which in itself means a corresponding reduction in real income per head. But the loss of this revenue, which formerly went to pay for part of Britain's food imports, together with the dislocation of international trade caused by the war, has also forced Britain to rely to a larger extent than before on the more costly home-grown food, which entails a further loss of productivity. And any benefit which might have been derived from the virtual disappearance of unemployment has been offset by the shortening of the working week. Obviously the sector which offers the widest scope for improvement is industry. And the next question must be, how can industrial productivity be raised?

Of the very many factors which affect output per man-hour some are beyond the control of the industry concerned. The great superiority which the U.S.A. enjoys over Britain in mining, for example, is due primarily to more favourable natural conditions, to the fact that

* *Comparative Productivity in British and American Industry.* National Institute of Economic and Social Research, Cambridge University Press, 1948; 263 pages, 182 tables, 3 charts, price 18*s*.

American coal mines are much easier to work than the British, or that American iron ore is richer than British. Incidentally, it is the high content of this ore which accounts to a large extent for the very high American productivity in the manufacturing of pig iron.

It is also clear that restrictions, whether on the part of industrialists or of trade unions, lower productivity; for cartels and similar devices, by restricting output and fixing prices, all too often penalise the efficient producer to the advantage of the inefficient; whilst labour's hostility to labour-saving devices must defeat the whole purpose of technical progress.

The size of the market is obviously another factor, for a certain minimum volume of output is necessary to make possible the use of the most economic methods of production. Nor can one discount such factors as the degree of standardisation of output, the organisation of production, the willingness and ability of the worker, and numerous other influences.

But by far the most important determinant of productivity in industry is the amount and quality of the productive equipment at the disposal of the worker. It can be said broadly that the more and better machines per worker, the higher the productivity, though this generalisation should not be carried too far, for a high output per man-hour may be achieved only at the cost of a disproportionate amount of manpower used indirectly in making and replacing the productive equipment. There is, however, little danger of this point being even approached by British industry. Horse-power per worker in the U.S.A. before the war was nearly double that of Britain.

The first and most important step in raising the productivity of British industry is therefore to increase the amount of productive equipment per worker. This obviously calls for a policy, economic, financial and social, with a view to promoting savings and encouraging their investment in productive equipment, to removing the restrictions which protect the inefficient producer, to removing the no less harmful restrictions on the part of labour which impede the fullest utilisation of the available machinery and sometimes even aim at deliberately reducing output, and so on. In short, it calls for a comprehensive and vigorous policy for wealth.

But the quantity of capital equipment is one thing, its quality and skilful exploitation quite another. And if the first is essentially a matter of economics and administration, the second is primarily a matter of science and technology. Unfortunately, scientists and technicians have so far had little say in British industry. In the U.S.A. (and in Germany) university-trained engineers constitute the great majority of top-ranking executives in industry, and scientists are industrial advisers wielding a real influence on the technological process. In Britain the management of industry has been confined almost entirely to business men, who have little or no knowledge of the technical side of their industry, and, with some outstanding exceptions, there has not been nearly enough collaboration between science and industry. In scientific research, British industry as a whole lags far behind American industry and, before the war, lagged well behind German industry.

Nor was there willingness enough to follow up the results of scientific research by subsequent technological improvements and innovations. Ever since the 1890s Britain has been losing—to the United States and Germany —her lead, not only in industrial power (which was inevitable), but also in industrial technique (which could have been avoided). The most striking illustration of this failure to keep abreast of technical progress is provided by Britain's backwardness in exploiting the chemical potentialities of coal. Before the war it was Germany which led the world in that branch of chemical industry which is based on coal as raw material.

But even if British industry should have a change of heart in this respect—and there are certainly signs that such may be the case—it would find itself greatly handicapped by the lack of suitably qualified personnel. That the flow of scientists and technologists in Britain is grossly inadequate has been made abundantly clear by informed discussions during the last few years. But the deficiency is not only one of numbers; it is also one of suitable training. There are no training facilities in Britain comparable to America's "Boston Tech." and "Cal. Tech.", or to Zurich's Polytechnic or the German *Technische Hochschulen*, which produce neither purely abstract scientists nor purely practical technologists but men who are a balanced combination of both. That is the type of man who matters most in advancing industrial and technical progress. Not only is it necessary to expand facilities for scientific and technical training, it is perhaps even more urgent to provide the right type of facilities. A policy for raising productivity which neglected to harness to itself all the potentialities of science and technology would be foredoomed to failure.

UNESCO PROGRAMME FOR 1949

THE Programme and Budget Commission of Unesco. Accent in Unesco's programme has shifted from reconstruction in war-devastated countries to constructional development in areas where, while not directly hit by the war, they were nevertheless in need of such aid. But the shift will not lead to immediate diminution in Unesco's activities in the cultural relief of war-devastated countries. Another feature of Unesco's programme is the provision of aid to member states wherein currency restrictions are in force. An example of what can be done is the Unesco Book Coupon Scheme.

Unesco is also undertaking a "Compensation Scheme" by which hard-currency countries should encourage students, teachers and technicians to study in and make cultural visits to soft currency areas, which would use the resulting gain in hard currency to purchase press, radio and film equipment, for scientific research, works of art and other cultural purposes.

The first meeting of the United Kingdom National Commission for Unesco was held in London on April 11. The Commission consists of 250 members representative of education, science and culture. Mr. George Tomlinson, British Minister of Education, was in the chair, and the speakers included Dr. Torres Bodet, Director-General of Unesco, and Dr. Julian Huxley, the ex-Director-General.

Science in the Home

J. GREENWOOD WILSON, M.D., F.R.C.P.
(Medical Officer of Health for Cardiff)

THE fundamental problem of housing is to provide a dwelling that is warm in winter, cool in summer and well ventilated, in short an environment that will promote the functional efficiency of human beings within the dwelling.

We need a housing environment that will give us a moving current of air that does not move so fast as to make a draught and that is neither too dry nor too wet, neither too hot nor too cold.

There is a wealth of convincing evidence to show the beneficient effect upon the working of the human body of a range of indoor temperatures from 60° F. to 76° F. with a degree of dampness, or relative humidity, not exceeding 70% nor less than 40%.

The human body has its own system for regulating and adjusting its temperature within the range that makes for its maximum efficiency. It exchanges heat with its surroundings by convection and radiation, and it *loses* heat to a considerable extent in warm weather by evaporation. By convection and radiation, the human body may either receive or give up heat, processes which are regulated by an extremely sensitive temperature control centre serving the function of a 'thermostat' within the brain. The mechanism of heat loss by evaporation from the skin is equally controlled by the brain centre. Under moderate temperature conditions evaporation plays a part in heat loss (27%) secondary to the combined effect of radiation (55%) and convection (15%). At temperatures above 95° F. evaporation accounts for nearly all the heat lost from the body. The water that was evaporated invisibly at lower temperatures becomes visible as drops of warm water on the skin (perspiration). The ease with which evaporation from the body goes on depends upon the humidity of the air surrounding it: the more humid the air the less readily can it take up any more humidity in the form of water vapour from the human skin, and the lower the temperature at which the evaporation appears as visible perspiration.

For the millions of homes that were built between the two world wars little attempt was made to apply scientific knowledge to design them scientifically for the benefit of the human beings who would live in them. Striking progress was made in the design and construction of factories but it is only lately that the principles worked out in the factory have been applied to the home. The first essential was to secure the necessary scientific data.

Measuring Comfort

The ordinary mercury-in-glass thermometer will measure the temperature of the air but it takes no account of humidity and is inaccurate for measuring radiant heat or air movement. Sir Leonard Hill invented, in 1914, a *katathermometer* which was designed to measure the cooling-power of the air on the human body. It is an alcohol thermometer with a bulb 4 cm. long and 1·8 cm. in diameter. The stem is 20 cm. long and has two graduations 5° apart—100° F., and 95° F.—about blood heat. At the top of the stem the bore is enlarged to form a small reservoir, so that the instrument may be heated several degrees above the higher graduation without risk of breakage. On the back of the stem is marked a figure which represents, for that particular instrument, the amount of heat lost as the thermometer cools through the range of 5° marked on the stem. In use, the bulb is warmed by immersion in hot water, until the alcohol (which is coloured red) reaches the reservoir at the top of the stem. Then the bulb is carefully dried and the thermometer suspended in the air. As it cools, the time taken by the alcohol to fall from the upper graduation to the lower is measured in seconds with a stop watch. Two or three observations are made and the average noted. The factor of the particular katathermometer used is then divided by the average cooling time and the quotient, known as the *cooling power*, is the rate of heat-loss from the bulb of the instrument. The disadvantage of this instrument in measuring the cooling power of human environment is that the bulb is so much smaller than the human body.

The *globe thermometer* was designed by Vernon in 1930 to measure the combined effects of radiation and convection upon the human body. It is a hollow copper sphere coated with black paint and containing an ordinary thermometer with its bulb at the centre of the sphere. The temperature of the instrument depends on its surroundings. If the walls and other surfaces around the globe are warmer than the air, the temperature recorded by the thermometer inside the globe will be above air temperature; if they are cooler than the air the globe thermometer temperature will be below air temperature. The globe temperature is also influenced by the speed of air movement. The globe thermometer reaches approximate equilibrium with its environment after about twenty minutes' exposure.

The *eupatheoscope*, or 'electric man' was designed by Dufton in 1932. It comprises a black-painted cylinder heated electrically to a degree depending on the coldness of its surroundings. The cylinder, of sheet copper, is 22 in. high and 7½ in. diameter and is made with the seam inside: the bottom is closed by a hard wood base ½ in. thick, whilst the top is of copper. The cylinder is supported at a height of 22 in. from the floor by the three telescopic legs of a photographic tripod projecting through the wooden base. The instrument is heated by a resistance-wire wound spirally on the outside and top of the cylinder in such a way as to produce a uniform surface temperature which is adjusted by thermostatic control and which is almost identical with that of the clothed human body over a considerable range of environmental temperatures. The instrument is fitted with two alcohol thermometers specially designed and sealed to give readings of 'equivalent temperatures', i.e. the combined effect upon the human body of air temperature, air movement and heat radiation.

The dampness or humidity of the air is most conveniently measured by the *wet and dry-bulb hydrometer*. This consists of two ordinary mercury-in-glass thermometers, one of which—the wet bulb—has its bulb covered with wet muslin. The dry-bulb thermometer measures the air

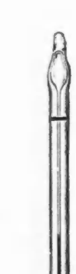
temperature. If the air is completely saturated with water vapour the temperature recorded by the wet-bulb thermometer is the same as the dry-bulb temperature, but when the air is unsaturated, the wet-bulb temperature is below the dry-bulb temperature. The drier the air the more rapidly is water evaporated from the wet-bulb and the more is that bulb cooled. Hence, at a given air temperature, the difference between the dry and wet-bulb temperatures increases as the humidity of the air diminishes.

The modern version of the wet and dry-bulb hygrometer is the *whirling hygrometer*. This consists of a pair of thermometers mounted in a frame which is provided with a handle, and the thermometers can be whirled rapidly so that the bulbs pass through the air at a considerable speed. The bulb of one of the thermometers is covered with thin muslin, and this is kept moist by a wick leading to it from a water reservoir at the base of the instrument. After whirling, the readings on the two thermometers are compared with a table which is supplied with the instrument and which gives the dampness or relative humidity in percentages. Suppose the readings show a dry-bulb temperature of 80° F. and a wet-bulb temperature of 75° F., then the relative humidity given in the table is 80%. The human body is not comfortable if the relative humidity is higher than 70% or less than 50%. Under ordinary conditions in this country the reading is constant in the upper limits of the range, 40% to 70%.

By patient use of all these instruments under all sorts of experimental conditions, scientists have been able to build up an accurate picture of what we *want* for human comfort, a picture which may be outlined as follows:

1. A room should be as cool as is compatible with comfort.
2. There should be adequate air movement. At room temperatures customarily maintained in winter in Britain—the speed should be about 30 ft. per minute; speeds below 20 ft. per minute tend to cause feelings of stuffiness.
3. The air movement should be variable rather than uniform or monotonous, for the body is stimulated by ceaseless changes of environment.
4. The dampness or relative humidity of the air should not exceed 70% and should preferably be much below this figure.
5. The average temperature of walls and other solid surroundings should not be appreciably lower than that of the air, and should preferably be warmer. The combination of cold walls and warm air often causes sensations of stuffiness.
6. Designers of gas and electric fires should see that radiant emissions from them are of the right wave-length; certain wave-lengths which are not absorbed by the skin induce feelings of freshness, others which are absorbed by the skin induce feelings of stuffiness. (The wave-lengths to avoid are 3, 4·1 and 4·7μ).
7. The air at head level should not be distinctly warmer than that near the floor, and the heads of the occupants should not be exposed to excessive radiant heat.
8. The air should be free from objectionable odours. In both Britain and the U.S.A., the perception of human odours has recently been taken as the principal criterion of the efficiency of ventilation. The only objection to the odours on health grounds is that they diminish appetite.

To achieve these ideal comfort conditions we rely on two forms of ventilation, the *natural* and the *mechanical*.



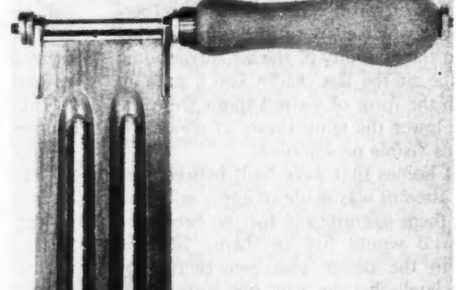


FIG. 1.—(*Left*) The Globe Thermometer.

FIG. 2.—(*Centre*) The Katathermometer.

FIG. 3.—(*Right*) The Whirling Hygrometer.

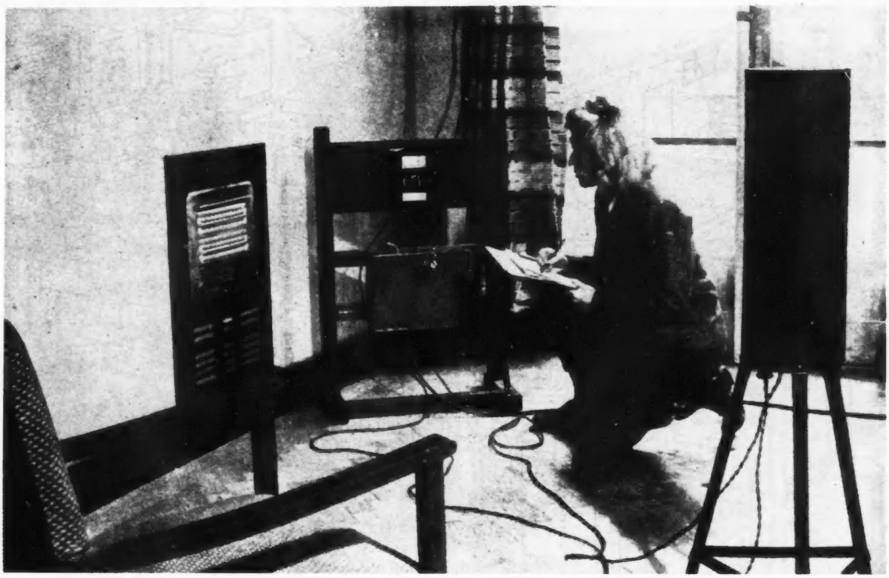


FIG. 4.—Studying a heating system from the point of view of human comfort with the eupathescope.

The former depends upon the 'natural' movement of air currents from one place to another. With mechanical ventilation, air is circulated through ducts from one part of a building to another. The ducts have openings at suitable intervals through which the air is either sucked from the room, the 'exhaust' system, or pumped into the room, the 'plenum' system. Air is sucked from or pumped into the system of ducts by a large propeller fan.

Seasoned travellers are familiar with the little cups which deliver forced air into each ship's cabin or sleeping car compartment. This is done by a 'plenum' or forced air system of ventilation. In the best plenum systems the air is cleaned and moistened by passing through fine water sprays and in winter also warmed, before it starts its forced journey through the ducts. This is, essentially, what is meant by the term 'air conditioning', except that in a hot climate the cleaned and moistened air would be cooled instead of being warmed.

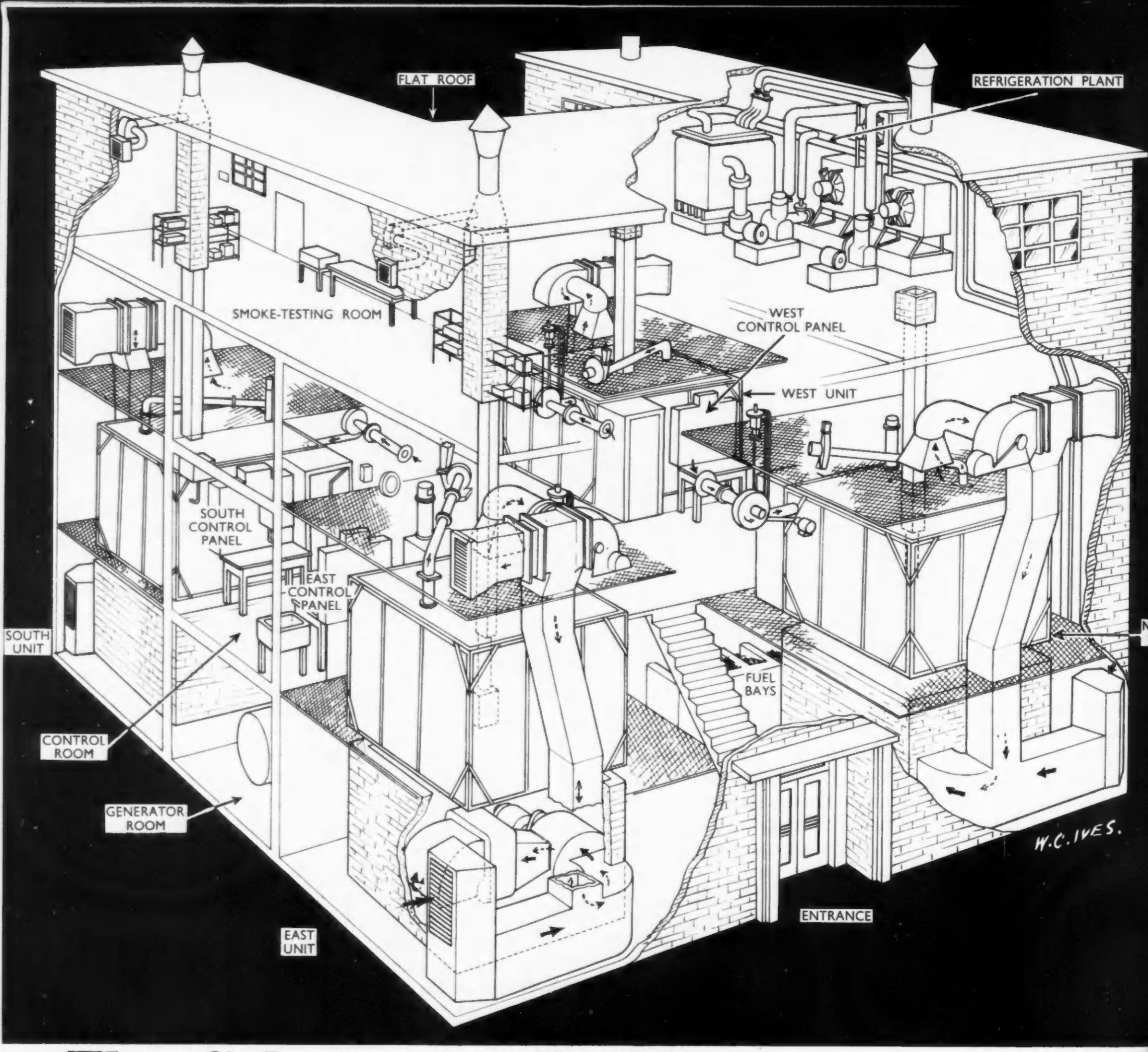
Ventilation without Draughts

Although air conditioning is commonly supplied to dwelling-houses in the U.S.A., in this country, reliance has been placed hitherto on natural rather than mechanical ventilation. The ordinary flue has been the great standby, with or without an open fire. Experiments have shown that even without a fire burning, a flue when unsealed gives almost three times as many air changes per hour in any given room as when it is sealed. The other standard method in this country has been the open window. The disadvantage of this method is the difficulty of achieving adequate ventilation without draughts, and as Florence Nightingale once said—to have the air in a room as fresh as it is outside, it should not be necessary to have it as cold. The occupier of a house with sash windows can arrange for himself a simple but satisfactory method of ventilation without draughts. All he needs to do is to fit a piece of wood about 1 in. thick and 4 in. wide along the window-sill so as to keep the lower half of the sash window permanently raised. The piece of wood, which completely blocks the opening, effectively prevents any air entering there. Instead, a continuous flow of air makes its way beneath the bottom edge of the top half of the sash window up between it and the upper edge of the lower half and then over that edge and into the room without causing any sensation of draught to the occupants.

It is a legal requirement that rooms without open flues must have ventilators fixed in the walls, but these are usually simple gratings which cause strong draughts in cold and windy weather. They are usually stuffed up by the occupants and their object thereby defeated. A post-war invention, the Colt constant flow ventilator, seems to provide a complete answer to these difficulties. It comprises a strong metal casing, housing self-adjusting vanes carried on silent plastic bearings. Ordinarily these vanes permit the uninterrrupted flow of air. When, with windy conditions outside the building, the rate of the incoming air approaches a speed which would be perceptible and cause a draught, the vanes gradually close, restricting the aperture and automatically controlling the rate of delivery.

Central Heating and its Advantages

The British climate makes it impossible to consider ventilation without heating. Ventilators and flues would not be stuffed up, windows would not be kept closed, if the insides of dwellings were sufficiently warm. In the average British home, the living-room or the kitchen is warmed and the rest of the house is unheated. The housewife performs many of her tasks in other rooms, which may be bitterly cold; and the warmed room is the only room in the house in which persons can relax or perform light work in comfort. During leisure hours the whole family must congregate around the fire in this one room.



The Calorimeter Building

When the Calorimeter Building was first shown to industrialists Sir Edward described its purpose in these words: "The apparatus has been designed to help us solve a problem of detection—to find out where the heat generated in domestic heating appliances ultimately goes."

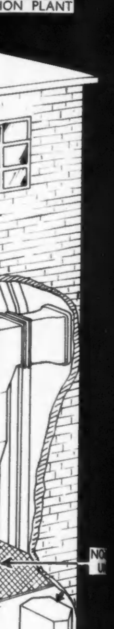
The Calorimeter Building, a four-storey structure covering an area of about 3,000 sq. ft., is designed to make complete and precise measurements that will reveal how the heat is transmitted by radiation, conduction and convection, how it passes from one room to another, and so on.

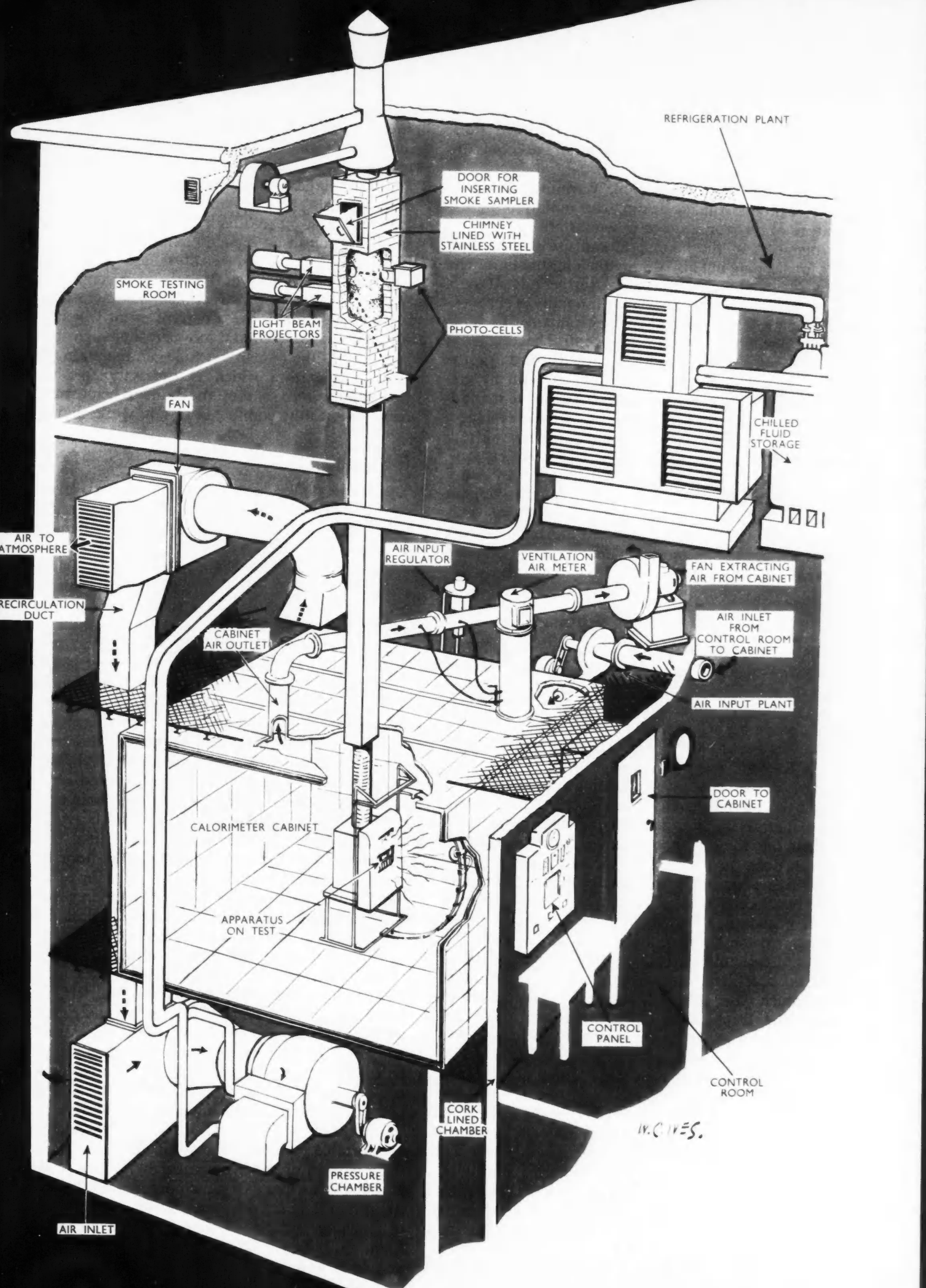
The Calorimeter Building contains four 'calorimeter cabinets', each the size of an average small living-room. In each cabinet domestic heating appliances can be installed and operated; the heat which passes through the walls, floors and ceiling of the cabinet is automatically recorded, and a direct measurement is thereby obtained of the total useful heat generated by the appliances under test.

The walls of the cabinet are constructed of $\frac{1}{4}$ in. plywood panels, covered on both sides with copper sheets. Thermo-couples are embedded at the mid-points of the copper sections directly opposite each other on the inside and outside of the plywood, so that the temperature difference across the walls, floor and ceiling can be measured and recorded electrically. The rate at which heat is flowing through the plywood can be determined from a knowledge of its thermal conductivity and the temperature difference between the inner and outer surfaces. The thermo-couple wiring system is arranged in such a way that the heat flow can be measured through any of the individual sections or any group of sections such as a complete wall. Each cabinet is air-tight and the amount of air supplied to the heating appliance can be measured accurately. The whole system makes it possible to test an appliance without its performance being affected by the measuring instruments, and the series of tests that are made give a complete picture of how the appliance behaves under different operating conditions and with different fuels.

The calorimeter cabinets are mounted in constant-temperature chambers extending from the ground floor to the underside of the top storey where the smoke tests are carried out. Each calorimeter cabinet is fitted with a chimney lined with stainless steel throughout its length. These chimneys terminate underneath cowls inside the smoke-testing rooms. A measure of the 'thickness' of the smoke passing through the chimneys is given by the proportion of light energy absorbed when a beam of light is projected across the flue; this absorption is measured by means of photo-cells. This photometric device is calibrated against an instrument which gives an actual count of the number of particles in a smoke sample.

Most of the instruments in the Calorimeter Building record their readings automatically in the control room on the first floor.





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In really cold weather, their backs and feet will still be cold owing to the draught from the excessive quantities of cold air drawn in from outside to pass up the chimney. The case of any member of the family outside the 'charmed circle' is even worse. In centrally-heated homes all the rooms are warmed to some extent, and if the central heating is not enough to produce comfortable warmth throughout the house, a little auxilliary heating can rapidly bring the temperature of any room up to a comfortable level. The various members of the household can use their rooms, not only for sleeping but also during their leisure time. The whole house can be used to the full. A further advantage is that in the warmed rooms the relative humidity of the air is lowered and therefore stored clothing remains drier. It is said to be uneconomic to provide a central heating plant in every one of the millions of homes planned for the Government's post-war housing programme, but by systems of district heating, every dwelling could have that advantage. In the U.S.A., where the system is well developed, a communal central heating plant may supply warmth and abundant hot water to upwards of 40,000 persons. There are a few schemes only in this country, and on a smaller scale, but the results show that the inestimable boon of constant hot water for heating and all other purposes can be provided for an extra rent of *5s. 3d.* a week. Against this must be offset an estimated saving in coal and electricity or gas of *7s.* per house.

Scientific Testing of Heating Appliances

A new impetus to the search for better and more efficient heating of dwellings has been given by the paramount need to conserve coal. Before the war, one-third of the total coal consumption in Great Britain for all purposes was used for domestic purposes, and of this huge total only one-fifth of its heating value was usefully employed. The remaining four-fifths was wasted. During recent years, industry has developed domestic heating appliances which are at least twice as efficient as the older ones. An example familiar to many is the stove in the living-room of 'prefabs', which heats the domestic hot water and supplies warmed air through ducts to the two bedrooms. Another is the 'closeable' living-room fire which again supplies hot water for all domestic needs and also provides hot air in quantities entirely adequate for cooking to a cooker in the kitchen next to the living-room. There are a number of varieties of these multi-purpose heating appliances, burning coal or coal products and performing many more functions much more efficiently than the open coal fire of the past. The Department of Scientific and Industrial Research tests and approves every newly invented domestic heating appliance before recommending it to housing authorities for use in their post-war housing programme. To assist them in their work, the Department have constructed a Calorimeter Building, which is really a scientific instrument designed for a special purpose—the measurement of heat. The whole building is a piece of experimental apparatus of such a size that every experiment can be carried out with a full-sized heating appliance. The broad principle underlying its use is the same as that adopted by the physicist in his laboratory when he measures the heat from half a thimble full of coal. He then uses a piece of apparatus which he calls a calorimeter. In the new building, each room is a calorimeter, and there are four of them, each 12 ft. square and 9 ft. high, that is about the size of an ordinary living-room in a small house, and each equipped with devices for recording the amounts of the different forms of useful heat and of heat loss. The tests will give a complete picture of the behaviour of the appliance under different operating conditions, and with different fuels. The building includes smoke-testing rooms for measuring by photo-electric methods, the amount of smoke produced by each appliance under test.

By all these means, scientists are busily engaged in working out systems of heating and ventilation which, when applied to the construction of new factories, buildings and homes, should give a current of air which is not too hot and not too cold and moves fast enough, but not too fast, so that the human machine can maintain the normal body temperature which is necessary for its efficient functioning and so that the human being may have a feeling of healthy comfort at rest, at work, and at play.

Job Analysis in the Kitchen

Attempts have also been made in recent years to apply to the oldest of all industries, the domestic, the methods of job analysis that have proved so successful in the services and in industry. In the making of an ordinary cake it is estimated that a housewife can take nearly 300 steps in an old-fashioned kitchen, compared with 50 steps, or less, in a well-designed one. She can walk from five to ten miles a day within her home if it is a long and rambling one, but need not cover more than one mile if things are properly arranged. In an ill-designed kitchen block, a woman can go from 50 to 60 times between the water tap and cooker, 40 to 50 between the cooker and dresser, and 30 to 40 times between the sink and dresser. In the average home, some 60 woman-hours of home-making activities per week are required. With shelves inconveniently high, unnecessary and fatiguing strain in stretching are caused. A low working bench causes backache, a high one strain on shoulders or elbows. No one should need to lift a heavy bucket full of water up, out, and over the edge of the sink. There should be a tap handy for filling the bucket at floor level. The answers to these problems lie in a planning of the kitchen block which allows for (1) the right working sequence, (2) working heights appropriate to the physical make-up of the average woman, and (3) adequate lighting.

This means that when standing in the kitchen, facing the window, storage for food and groceries, including the refrigerator, should be together on the left, with glass, china and general utensils storage on the right, the sink and cooker being between with the preparation counter adjoining the food storage side. The preparation counter, or working table, the sink draining-boards, the top of the cooker and all other working levels forming, as far as practicable, an extensive counter running right round the room, should all be 3 ft. above floor level which makes for comfortable posture and convenient elbow angle at work for a woman of the average height. A short woman can always place a piece of duck-boarding in front of the sink to prevent fatigue from undue stretching. To prevent strain in reaching up, shelves should not be higher than 6 ft. Lighting, both natural and artificial, should be adequate and so arranged that the worker does not get in her own

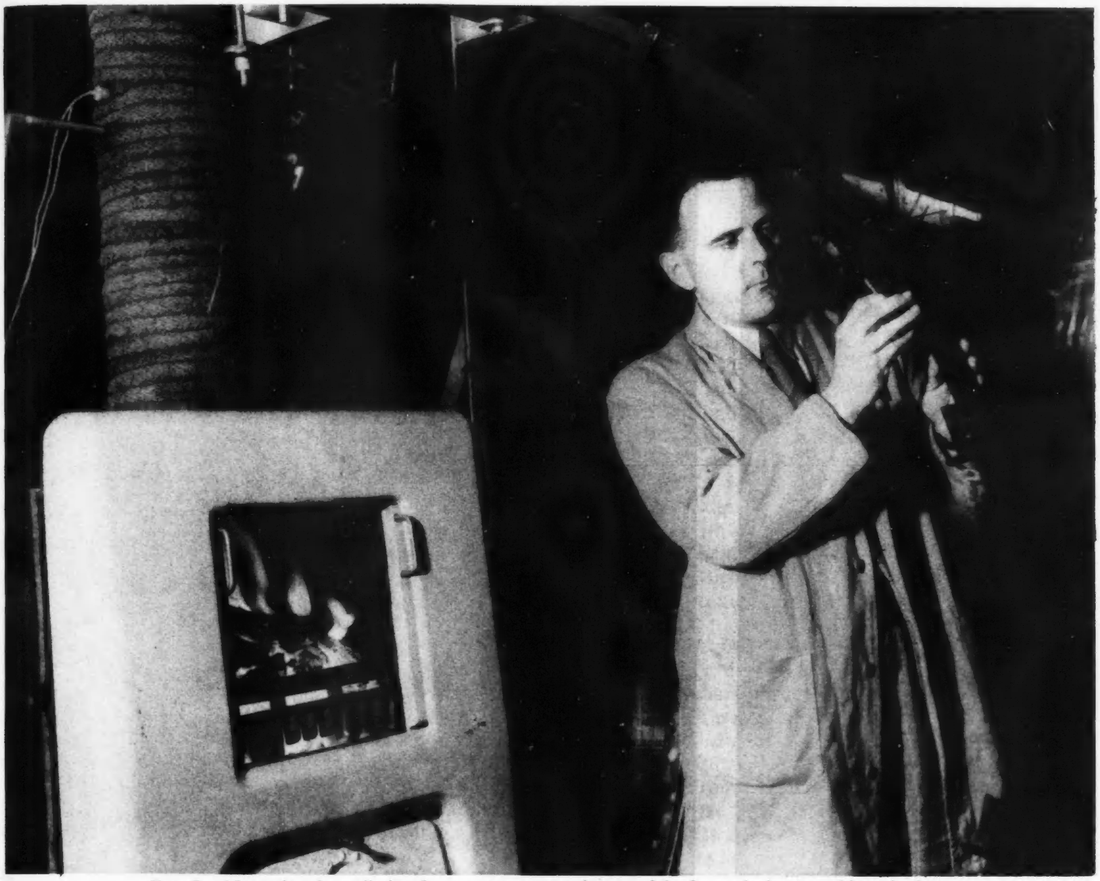


FIG. 7.—Measuring the radiation from a stove on test in one of the four calorimeter cabinets in the Calorimeter Building.

light and that doors of cupboards, cooker and refrigerator, as far as practicable, open to let in the light rather than to shut it out.

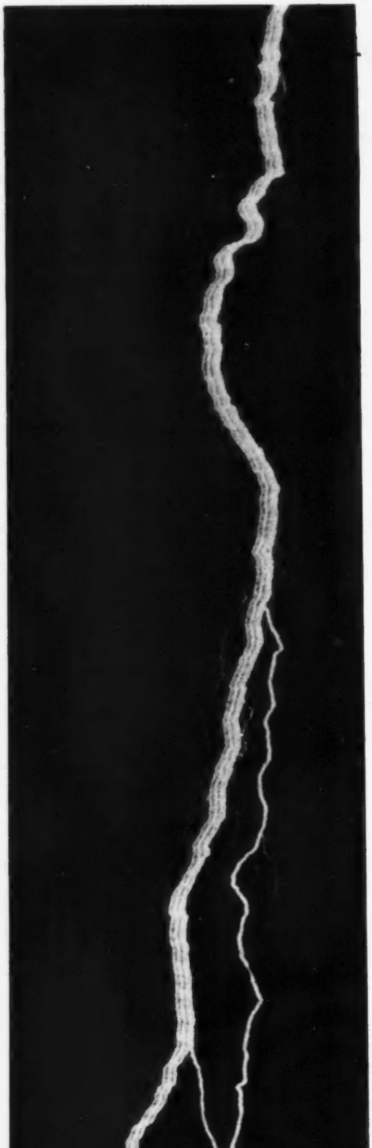
For adequate artificial light and to prevent shadows, fluorescent lighting is a great boon. It provides a 98% daylight effect and a high degree of illumination without glare, and gives a degree of eye comfort that has to be experienced to be believed. It is the answer to the eye strain and mental illness that result from gloom.

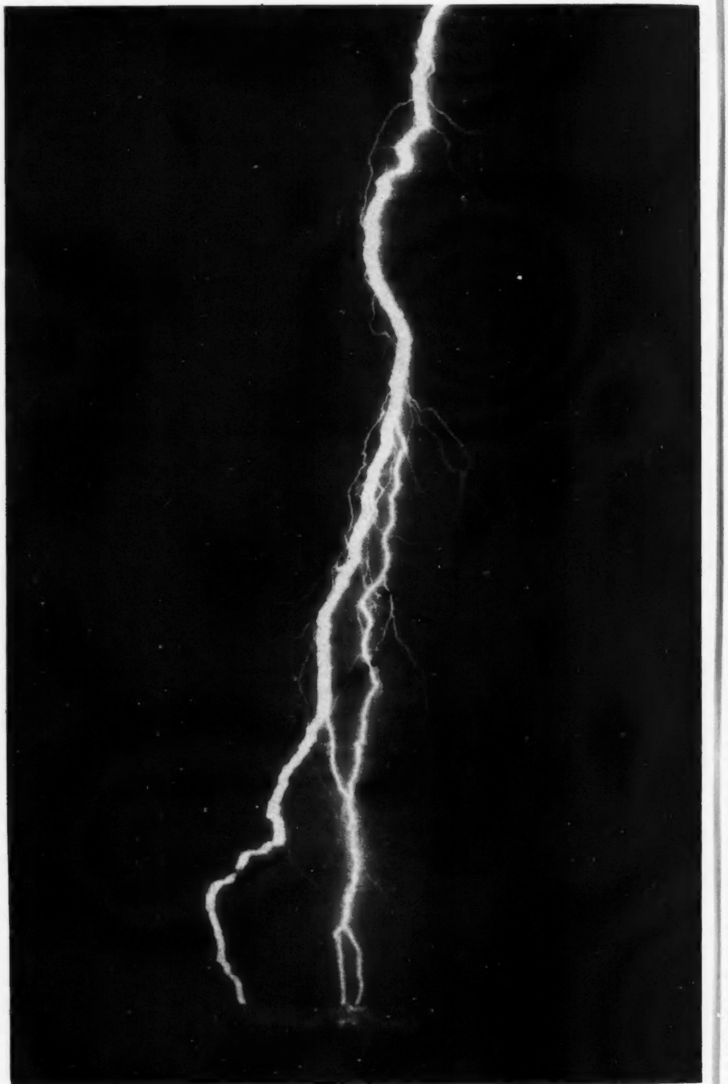
The 'grumble point', as it is called, of minimal illumination, is matched by the 'limit of pain' caused by 130 decibels, the units of measurement of noise—the noise of an aeroplane propeller at five metres measures 120 decibels. Excessive noise, one of the evils of our age, may be reduced in the ordinary dwelling without great expense by lining walls and ceilings with certain materials, for example glass-wool. 'Most of these have the additional advantage of preventing heat from leaving the house or cold from entering, in winter, and vice versa, in summer.

Space permits only a passing reference to the other desiderata in housing for health, e.g. better placing and lagging of pipes to prevent freezing in cold weather; smooth surfaces with minimum cracks and crevices to prevent vermin infestation as well as germ-carrying dust; refrigerators; airing cupboards; sheds away from the house, but reached by paved access, for storage of fuel, bicycles, tools, work-bench and garden implements; laundering facilities away from the kitchen, particularly as this tends to become conveniently a kitchen living-room; and, in the back porch, tradesmen's delivery hatch, and meter cupboard for easy meter reading. All these, together with the suggestions made generally for kitchen planning and equipment, when added to the other recommendations in this article, would provide a healthy home.

To complete the picture of housing for health you have still to consider the placing of your house in what the planners call a 'neighbourhood unit' of population not exceeding 10,000 persons, with a 'neighbourhood centre' with adequate open spaces and with shops, schools, health centres, homes for midwives and other amenities all suitably placed, the 'neighbourhood unit' in turn to go with other units to form one comprehensive scheme of town and country planning.

(Figs. 1–3 are from the M.R.C. booklet, "Environmental Warmth and its Measurement", by T. Bedford, and are reproduced by permission of the Medical Research Council. Fig. 4 is a Building Research Station photograph.)





A SPORTS PHOTOGRAPHER'S SCOOP

Fig. I.—This is the kind of lightning photograph which can be obtained without any elaborate apparatus; it was in fact taken with an ordinary press camera by a newspaper photographer who was covering a cricket match. A reproduction of the picture in a newspaper attracted the attention of our author. An enlargement from the original negative (*left*) revealed that the flash consisted of five successive discharges which change their paths not less than twice, thus producing three separate strikes to earth—seen in the original untouched photograph (*above*).

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Many DISCOVERY readers are already collaborating in the Thunderstorm Survey of the British Electrical Research Association, which now seeks further assistance and hopes to enlist the services of keen photographers. In this article the Association's expert on lightning explains the value of such pictures.

Photographing Lightning

R. H. GOLDE, M.I.E.E., A. Amer. I.E.E.

WHEN Sir J. J. Thomson was once asked by one of his new students where to get a certain type of apparatus which he had just been told to use, his reply is reported to have been "You make it". The time when a research worker had to 'make' a standard piece of equipment is past, and this applies to the investigation of lightning as much as to any branch of science. In fact, lightning is being examined by every type of recording instrument likely to produce a positive result and, in addition, special instruments have been constructed to probe into the secrets of the lightning discharge.

Yet of no other branch of science can it be claimed with equal justification as of the lightning discharge that so much knowledge has been gained, and can still be gained, by so simple a device as an ordinary photographic camera. In what follows, a brief account is given of the knowledge of the lightning discharge as derived from photographic evidence and by means of a few examples it will be seen how much more useful information can be obtained from lightning photographs. In this way it is hoped to interest amateur photographers in a field which is likely to be new to most of them but in which they can make a real contribution to scientific knowledge.

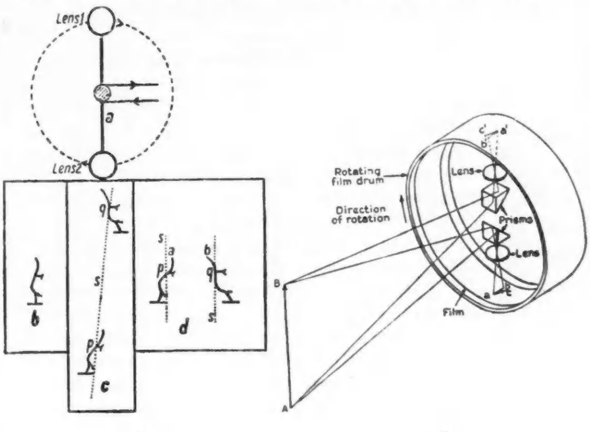
The story of the photographic investigation of lightning begins in 1884 when Kayser published a photograph which he then obtained and which shows most of the characteristics of a lightning stroke. The flash reproduced in Fig. 5 is seen to consist of several highly luminous discrete discharges, now termed 'component strokes', the individual strokes following exactly the same path which, in the above case, was shifted horizontally by strong wind. From the known velocity of the wind, the distance between lightning flash and observer, and the dimensions of the camera, the time intervals between the individual strokes were determined at 0·362, 0·041 and 0·074 seconds.

There are two further interesting facts which can be observed from Kayser's photograph. The first stroke on the left is heavily branched whilst succeeding strokes show no branching. Although not all first strokes are branched, the absence of branches in later strokes has been confirmed in all known lightning photographs. The second notable feature is the persistance of luminosity in the first stroke. This type of discharge, now termed a 'continuing stroke', is not a very frequent phenomenon and can readily be distinguished from the more common type of stroke which shows clearly defined sharp edges, both at the front and back of the individual discharge paths.

It was Weber who appears to have first conceived the idea of turning his camera deliberately about a vertical axis so as to resolve the details of a complete lightning flash. Many photographs have been obtained by this simple method which can be copied by any interested amateur. One of the most interesting examples is reproduced in Fig. 3*a* which, in addition to the characteristics already mentioned, shows a pronounced fork effect of the lightning flash which hits the earth at two separate points. The corresponding photograph, taken with a camera moved by hand (Fig. 3*b*), shows equally clearly that the two separate hits did not occur simultaneously, but are due to separate strokes, the second component stroke leaving, for an unknown reason, the track of the first stroke and blazing its own path to earth which is then followed in every detail by later strokes.

These observations induced Sir C. V. Boys to design and construct a rotating camera in which the rather inaccurate movement by hand was replaced by a uniform speed of rotation and which, in addition, incorporated two lenses rotating in opposite directions. The resulting deflections of the pictures of a vertical path such as a lightning stroke then enables the time characteristics of the discharge to be resolved, and it is this type of camera on which our accurate and statistical knowledge of lightning strokes is based.

The most important feature resolved by a rotating camera is the existence of a faintly luminous 'leader stoke' which precedes the lightning stroke proper and which, so to speak, gropes its way from the cloud to earth. This is followed by the 'return stroke' which proceeds from earth to cloud. It is this return stroke which produces the intense luminosity which enables lightning to be photographed even with a small aperture. While the total duration of a complete lightning flash may amount to one second and is, on an average, of the order of 0·3 second, the highly luminous part is confined to about 10 millionths of a second, so



(*a*) (*b*)

FIG. 2.—Schematic diagrams of two types of Boys camera: (*a*) with rotating lens and stationary film (*after Schonland*), (*b*) with moving film and stationary lenses (*after McEachron*).

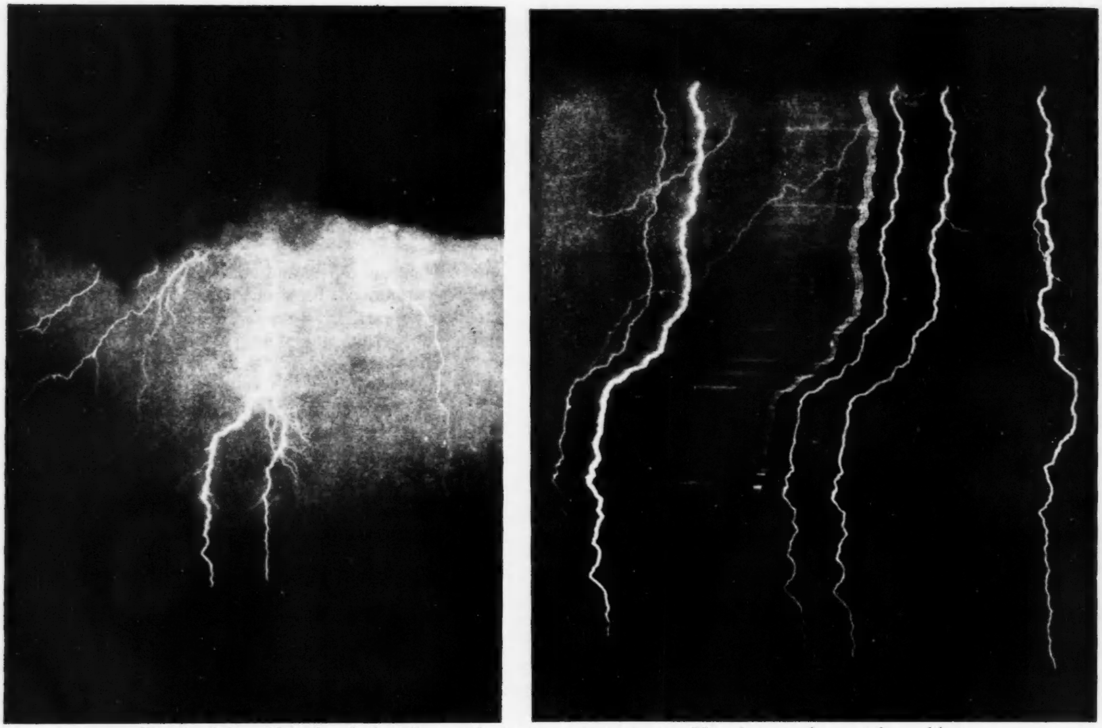


FIG. 3a (*left*).—Lightning flash strikes earth at two separate points. The photograph was taken with a stationary camera. FIG. 3b (*right*).—A photograph of the same lightning flash, but taken with a camera moved by hand, the camera 'panning' through 120° in about a second. (*B. Walter, Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, 1909*).

that even an average flash consisting of three component strokes is confined to some 30 millionths of a second. This figure indicates the small degree of reliance which can be put on eye-witness accounts of the 'movement' of a lightning stroke and it stresses the importance of obtaining photographic evidence of so fleeting a phenomenon.

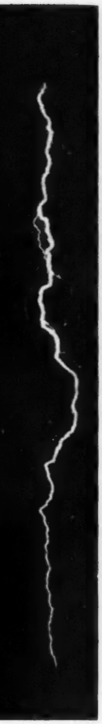
Although a rotating camera of the Boys type is required to detect the directions of propagation of leader and return stroke and to determine their velocities of propagation, an ordinary photograph shows occasionally quite clearly the faint leader stroke preceding the first lightning stroke. Such an example is seen in Fig. 3*b*.

From the evidence collected over several years, much is now known about the mechanism of the lightning stroke. However, many more photographs are required by the research worker to complete the story. In fact, in the hands of the expert, a lightning photograph may reveal much more than appears at first evident. Fig. 1 shows the print of a photograph taken last summer by Mr. F. A. Armstrong of the Kemsley Newspapers Ltd., who watched a cricket match at Old Trafford and obtained this beautiful photograph almost as a by-product. On examination under a magnifying glass, the original negative shows a fine structure which can be seen in the accompanying enlargement. This flash is thus seen to consist of five component strokes which change their path no less than twice, thus producing three separate hits to earth. Unfortunately the distance from the flash to observer is not known, but even so this photograph reveals details which may exercise the mind of the research worker for some time to come.

When attempting to obtain a lightning photograph, special care should be taken to include the earth termination of the discharge. From theoretical considerations it appears likely that when the lightning leader stroke has approached earth to within some 10 to 100 ft., an electrical streamer discharge is initiated at the earth's surface and this grows upwards to meet the down-coming leader stroke. The chance of photographing this phenomenon is rather remote in view of the high degree of halation produced by the return stroke. To overcome this difficulty, a small aperture must be used, and it is in this way that the only two known photographs of upward streamers from earth have been secured. One of these is reproduced as Fig. 4.

However, even if the chance of obtaining equally striking results is comparatively small, important information can be obtained from a knowledge of the height above earth at which a last abrupt change in direction of the lightning path occurs. Such sudden changes are particularly noticeable in flashes to tall structures such as chimneys, wireless masts, or captive balloons which, without exception, are of considerable interest to the expert.

Another open question which requires photographic evidence is the occurrence of lightning discharges from the top of a thunder cloud into the upper atmosphere. Such discharges have been described by several eye-witnesses, but no photographic evidence of this interesting type of discharge is known.



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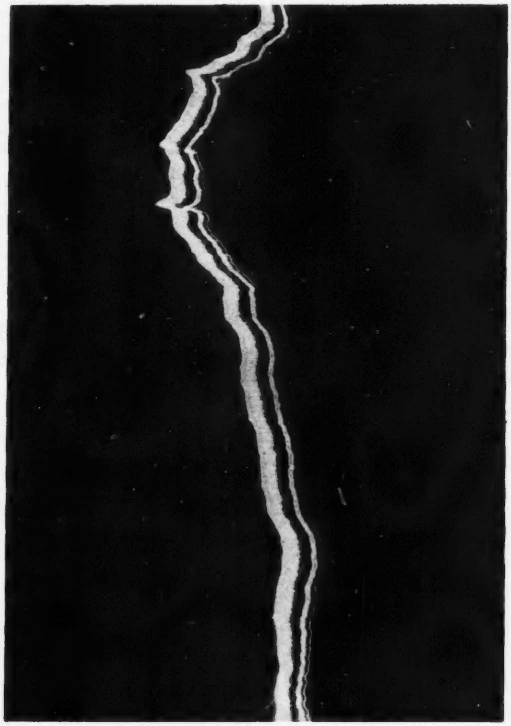

FIG. 4 (*left*).—One of the only two known photographs showing streamer discharges rising from the ground to meet the down-coming leader stroke. (*After K. B. McEachron and W. A. McMorris*). FIG. 5.—The first lightning photograph ever published. Taken by H. Kayser in 1884, shows that the lightning flash consists of a number of discharges on 'strokes'; the path of the flash is seen to be shifted by strong wind.

The protection of buildings or trees against lightning, protection against accidents of human beings and animals, and similar problems are greatly assisted by photographic evidence of actual occurrences taken before essential clues may have been obliterated. Such photographs should, as far as possible, include all visible traces left by the incident and should also include a general view of the surroundings of the point struck, covering an area of several hundred feet radius around the point of incidence.

Finally the puzzling problem may be mentioned of the extremely rare special types of lightning known as ball-lightning, ribbon-lightning, pearl-lightning, and similar phenomena. Photographic evidence of such cases is highly valued by research workers.

Technically, lightning photography represents little difficulty to the photographer. Any type of camera with the focus adjusted to infinity and with a small stop is quite sufficient for the purpose. At night, the camera with open shutter may be directed towards a storm centre and, when a flash occurs within the field covered, the shutter is closed and the plate is changed or the film moved on. In daylight the problem is more difficult, but fogging can be prevented if the rate of discharges is watched and the shutter opened shortly before a new discharge is expected. Existing devices to trigger the shutter automatically before the onset of a lightning stroke are unfortunately beyond the means of the amateur.

Whether the camera is kept stationary or whether it is moved, is left to the individual observer. If a movement is attempted, the camera should be turned in a horizontal plane through an angle of about 120° and at a rate of about one swing per second.

To be of greatest scientific value, a lightning photograph should be accompanied by the fullest description which the observer can give. This should include the approximate distance between flash and observer (this can be estimated by remembering that each second time interval between lightning flash and onset of thunder corresponds to 1100 ft.), place and time of the occurrence, description of camera and exposure, and any information on the visual impression of the flash, sound of thunder, point struck, storm movements, fall or absence of rain, direction and strength of wind, and any other information which the observer can give.

To the expert, the negative of a lightning photograph is of much greater value than any print. Successful photographers are therefore requested to send their negatives on a short loan to the British Electrical and Allied Industries Research Association, 5 Wadsworth Road, Greenford, Middlesex, where they will be examined and catalogued. The Association is willing to answer special queries by correspondence which should be headed 'Lightning Photographs'.

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FIG. 1.—Archimedes used his hydrostatic 'principle' to distinguish gold from gilt. His technique is regularly used in gem testing. In this picture the specific gravity of a gemstone is being determined by the hydrostatic method.

Modern Methods of Gem Testing

ROBERT WEBSTER, F.G.A.

THE use for the purposes of adornment of brightly coloured and lustrous minerals has been known from ancient times, and for countless centuries the only distinction between the various kinds was based upon their colour. It was not until the nineteenth century that any serious attempt was made to place the new-found knowledge of mineralogy and chemistry to the aid of the trader in gemstones, who, in fairness be it said, had little difficulty in distinguishing between the few well-known gems and glass, the only important counterfeit with which he had to contend.

With the close of the nineteenth century and the beginning of the twentieth the position changed. Composite stone with a top of garnet fused to a base of glass defied the hardness of a file—the tool with which the jeweller was wont to test for imitations. In 1885 the *reconstructed ruby* emanated from Geneva; stones made by fusing in a crucible small fragments of real ruby, with the addition of a small quantity of potassium bichromate to improve the colour. Crude as these stones were, they were successful enough to 'catch out' the trader, at least until the story of their manufacture was disclosed. The production by Verneuil in 1904 of the synthetic ruby, by the use of an ingenious inverted oxy-hydrogen blowpipe of his own design*, proved a signal success for the chemist and became a headache for the jeweller, who today has to contend with some eighty different species of gem materials, many types of synthetic gemstones, new variations in composite stones and different types of glass and modern plastics.

Beset with such problems it is little wonder that the jeweller realised the importance of calling science to his aid, in fact he has now been forced to become something of a scientist himself. The possible high value of the specimen to be tested, and the probability that it be mounted in a setting from which it may not be removed, limit the methods of attack and precludes the use of chemical analysis, except in special cases. The worker must therefore rely mainly on optical tests; and chiefly those depending upon measurement of the index of

* See "Synthetic Minerals", DISCOVERY, May 1948, Vol. 9, No. 5, pp. 139–142.

FIG. 2.—THE TULLY REFRACTOMETER.

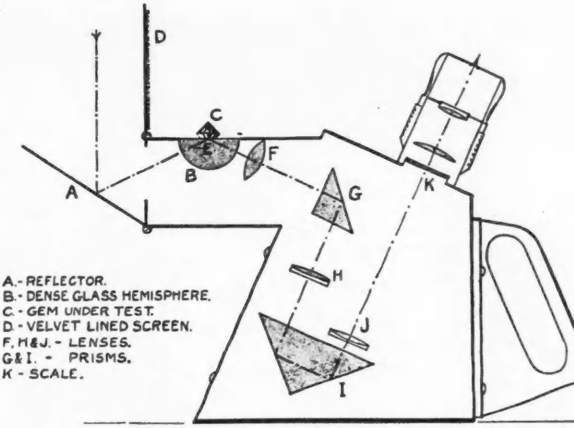


FIG. 3.—The Instrument's Optical System.

The instrument depends on the fact that there is total internal reflection of the light entering the glass hemisphere AB (Fig. 4) at an angle greater than the critical angle IOM when a stone to be tested is placed on the glass hemisphere; a drop of liquid with an optical density greater than the stone is placed between the stone's flat facet and the glass in order to displace the air film. The glass hemisphere must also have a refractive index greater that the stone to be tested. All rays that enter the hemisphere at a greater angle than IOM will be returned through the opposite segment BOR; rays at a lesser angle will pass out through the stone leaving the area MOR comparatively dark with the shadow edge marking the critical angle, which differs for stones of differing refractive indices. Thus the optical system coupled with a scale calibrated in indices of refraction allows the shadow edge crossing the scale to give direct measurement of the refractive index (indices in the case of doubly refractive stones) of the specimen. The scales illustrated (Fig. 5) show a reading (*a*) for a singly refractive stone, spinel; (*b*) for doubly refractive stones.

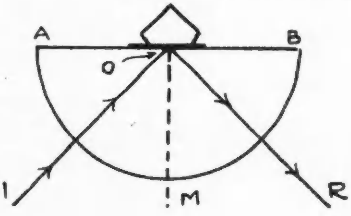
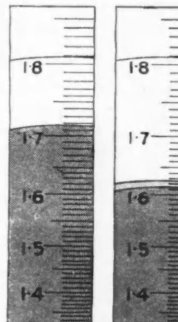


FIG. 4.—(*above*).

FIG. 5.—(*right*).



(*a*). (*b*).

refraction, upon the type of refraction and upon the effects depending on colour. Should the stone be unmounted, valuable information may be obtained by the determination of specific gravity, which is very constant for pure materials—and gemstones are the purest forms of many well-known minerals.

For his instruments the scientific jeweller turned to the equipment of the mineralogist; hardness points, the microscope, the balance and the dichroscope were early brought into the service of gem testing. There was no easily operated instrument which could be used to measure the indices of refraction of gems and the need for a positive means of so doing led Dr. G. F. Herbert Smith, an eminent minerologist, to devise a jeweller's *refractometer* whereby the bending power of the stone to a ray of light is recorded as a shadow edge on a scale calibrated in indices of refraction. As the science progressed other instruments were found to be of value, and in particular that powerful weapon of the physicist, the spectroscope, which, in the hands of workers in this country, has been found to give the greatest assistance in gem distinction.

Briefly, the major problems of the gemmologist consist of the identification of the mineral species of the stone and to ascertain whether it was formed in Mother Earth or is a product of the chemist's laboratory. The measurement of refractive index, coupled with one or more confirmatory tests, will establish the stone as belonging to a definite species, while microscopic observation of its internal structure will determine its origin. It is during this scheme of testing that imitations of glass and plastic, and the composite stones, reveal themselves.

The constant of specific gravity may be determined by weighing the stone in air, and then when immersed in water (or liquids of low surface tension for very accurate results), and computing the density by applying the Principle of Archimedes. This method is time-consuming and in general practice is only carried out in exceptional cases, for an approximate density is sufficiently satisfactory for most testing needs. Such approximation is conveniently carried out by the use of high density liquids, such as bromoform (density 2·89) and by methylene iodine (density of 3·32), both of which can be diluted with α-monobromo-naphthalene. For values higher than 3·3, Clerici solution, an aqueous solution of thallium malonate and formate (with a density of 4·15) is used. As a stone will float on a liquid denser than itself and sink in one less dense, the approximate gravity of a stone can be found by noting between which of two liquids of known density the specimen floats and sinks.

The refractive index is measured on the jewellers' refractometer, to which reference has been made, but as these instruments are unique in that they are made solely

FIG. 6.—Observing the absorption spectrum of a gemstone with a spectroscope.

FIG. 7 (*left*).—Examining the internal structure of a gemstone under a binocular microscope.

FIG. 8 (*right*).—A Rayner refractometer in use. The contact liquid is being applied to the prism before placing the gemstone in position.

for gem testing they deserve further discussion. The refractometers, of which there are now a number of differing types, depend upon the projection on to the scale of the shadow edge due to the critical angle of total reflection of the two media in contact; one being the dense glass of the instrument and the other the stone under test. The instruments have certain limitations: for instance, it is necessary that the stone being tested should have a flat polished facet; and that the 'dense glass' of the instrument and the contact liquid should have an index of refraction greater than the gemstone to be tested.

In the earlier Herbert Smith refractometers, readings were limited (by the dense glass and the contact liquid used) to about 1·79, thus precluding clear readings for many garnets. The later Tully and Rayner instruments are made with glasses which enable readings up to 1·86. Modern refractometers allow the indices of most gemstones to be read off directly, although in white light the shadow edge (or edges, in the case of doubly refracting stones), are blurred spectra which precludes accuracy greater than to the second place of decimals. By the use of the monochromatic light from sodium-vapour lamps, accuracy can be obtained to the third place of decimals and the amount of birefringence in doubly refractive stones be measured. Further, with the sharp shadow edges so obtained it is possible in many cases to determine the *sign* of refraction and thereby obtain additional information. There are, however, several gemstones which have higher refractive indices than these instruments will read and hence give a 'negative reading'. Such stones include diamond, zircon, sphene and the green garnet known as demantoid.

Several attempts have been made to construct instruments which will read high enough to cover those stones which give a 'negative reading', and there are in existence at least two instruments which will give comparatively high readings. One of these employs a prism made from a clear piece of the mineral *sphalerite* (zinc blende), and the other with what is possibly the finest medium for such a 'dense glass', that is diamond itself. The cost of the latter instrument precludes its extended manufacture, and further, requires the use of unpleasant liquids if the higher ranges are to be utilised. Another special type of refractometer, devised by Anderson and Payne, employs a 'dense glass' of synthetic white spinel which, although reading to only 1·70, has several advantages. The hard spinel resists surface scratching, which is a common trouble with the soft glass used in the standard instruments. Further, the low dispersion of spinel enables the two shadow edges shown by doubly refractive stones to be clearly seen without the aid of monochromatic light, also the scale with its more limited range is more open.

The knowledge obtained from the study of crystallography tells the gemmologist that certain crystal materials which serve as gemstones affect light in a particular manner; in that they split a ray of light into two rays which have differing properties. The determination of the

FIG. 9.—This photomicrograph shows inclusions in a Burma ruby.

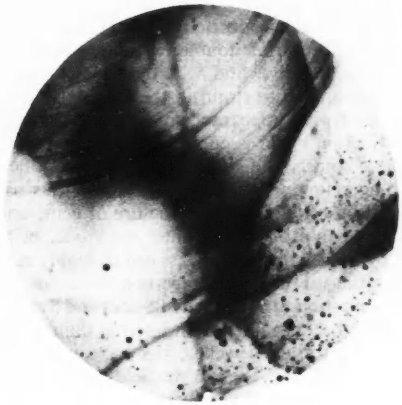


FIG. 10.—The curved striations and gas bubbles reveal that this ruby is synthetic.

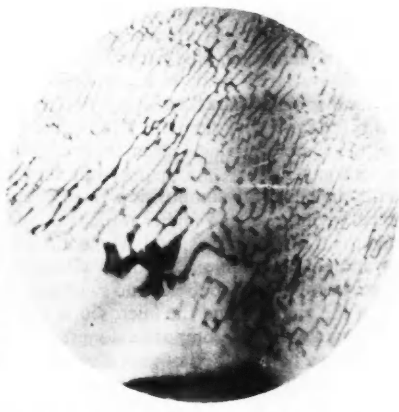


FIG. 11.—The typical 'feather' structure of Ceylon sapphire; the microscopic cavities are believed to be filled with liquid carbon dioxide.

GEMSTONES AND THEIR MICROSCOPIC HALLMARKS

existence of double refraction will therefore provide some information as to the nature of the gemstone under consideration.

The phenomenon, as has just been mentioned, may be observed on the refractometer when monochromatic light is used, but is more usually detected in the case of coloured stones by the *dichroscope*, an instrument employing a rhomb of Iceland Spar, the strong double refraction of which produces in the eyepiece of the instrument two images of the square aperture which pierces the front end of the tube containing the spar. When the stone is held in front of the square aperture a double image is seen through the eyepiece; then either two different colours, or two shades of the same colour, may be observed in the two images, or these may remain of the same tint however much the stone is turned. The existence of two shades of colour, the so-called 'twin colours', proves the stone to be doubly refractive, but the converse does not hold true, for some doubly refractive stones do not show this differential absorption of light. A polarising microscope, containing besides the usual magnifying system special prisms or polaroid discs for the production of polarised light, is often used for the detection of double refraction. The method is particularly sensitive and will detect any anomalous double refraction due to strain in the material. The latter is shown by a typical appearance of light and dark patches ('tabby extinction') and is common in many garnets and the synthetic spinels and thus assists their identification.

An ordinary low power ($\times$ 25) microscope is used for the observation of the internal structure of gemstones, the only difficulty, that of 'getting into' the stone, being surmounted by immersing it in a glass cell of highly refractive liquid;* by the use of a sub-stage condenser, or by dark ground illumination. In the United States and Switzerland, binocular microscopes fitted with internal illumination are made specially for the jeweller, but have not yet found favour in this country. Seen in the field of the microscope a natural gemstone shows small crystal inclusions, 'feather structure' or straight lines or colour zones which often meet at definite angles. Synthetic ruby and sapphires show curved lines or colour bands and often characteristically shaped gas bubbles. The synthetic spinels, now made in so many lovely shades, mostly imitate stones of another species, such as aquamarine, blue zircon, green tourmaline or kunzite, and are rarely made in colours comparable to those of natural spinel, hence their properties are different from those of the stone they simulate. Unlike the synthetic corundums the synthetic spinels never show curved structure lines and gas bubbles are sparse, but they have a slightly different chemical composition from that of the natural spinel giving rise to a higher refractive index than for natural stones of the species, and, as mentioned earlier they show anomalous double refraction. Glass imitation gems are seen to contain gas bubbles and swirl marks which are typical of the material and the microscope also reveals the lack of homogeneity of composite stones.

In recent years a new method of gem distinction, that of absorption spectroscopy, has been elaborated. As far back as 1866 Sir Arthur Church observed absorption bands in almandine garnet and in zircon; F. J. Keeley and E. G. Wherry, among others, advanced the technique in the realm of mineralogy but included some reference to gemstones in their work, while Anderson and Payne in this country have brought the use of the spectroscope to the fore in applied gemmology, and today more than twenty gemstones may be positively identified by this means alone. The method is simple, the instrument small and the absorption bands are so characteristic that qualitative observation by the spectroscope of light reflected from or transmitted through the stone is all that is necessary. Particularly useful is this method in the cases of zircon, diamond and demantoid garnet which are above the range of the refractometer, for these three stones show characteristic absorption bands. Further, distinction can sometimes be made between natural and synthetic stones by observation of the absorption spectra; this is so in the case of the yellow and blue shades of synthetic spinel, and in the synthetic sapphire made to imitate the alexandrite, while the existence of a fine band at 4500 Angstroms will determine a blue sapphire to be natural and not synthetic. Both jadeite ('Chinese jade') and turquoise show bands which are indicative of their nature, a fact which is particularly valuable as these stones are so often fashioned with curved surfaces which preclude the use of the refractometer. The colour filter which passes a band of red and a band of green light has a value in testing emeralds and some blue synthetic spinels and pastes, for these stones show red when viewed through such a filter.

Fluorescence effects as shown by an ultra-violet lamp have been found useful for identifying diamonds, Ceylon yellow sapphires, synthetic spinels, zircons and for the synthetic emeralds now being manufactured in the United States. The variation in the transparency of different gemstones to X-rays can be utilised in special cases, such as a doublet with a diamond top and a base of glass; a black diamond can, owing to its complete transparency to the rays, be quickly determined, even it it be in a setting.

The fact that diamonds may be artifically coloured green by α-particle bombardment from radium emanations requires a test for radioactivity on all suspected stones; this is simply carried out by placing the stone on a photographic film and leaving tor some hours; on development the film will be fogged if the stone be radioactive.

The intention of this résumé has been to show something of the techniques used in present-day gem testing; to show something of the advances made during the past forty years, an advance ever going on, that has led to the formation of the new science of gemmology. Little has been told of the stones themselves—that was not the intention of this article; nor of the work of the lapidary, without whose craft the beauty of these precious things would for ever be concealed.

READING LIST

The standard work on gems is G. F. Herbert Smith's *Gemstones* (Methuen), of which a new edition is being published this summer; this contains a large section on gem testing. The subject of gem testing is fully dealt with in the following two books: *Gem Testing*, by B. W. Anderson (Heywood, London, 1947); *Practical Gemmology*, by R. Webster (N.A.G. Press, London, 1947).

(Figs. 2, 4 and 5 are taken from the latter book; Fig. 3 is from R. Webster's *Gemmologist's Pocket Compendium*.)

* α-monobromonaphthalene and methylene iodide with refractive index of 1·66 and 1·74 respectively are the liquids most commonly used.

Far and Near

Radio-isotopes exhibited at B.I.F.

For the first time at the British Industries Fair, radioactive isotopes were on show. Products of the Harwell piles, they formed part of the exhibit arranged by the Atomic Energy Division of the Ministry of Supply, whose catalogue revealed that sixty of these artificial radio-elements are now available.

Harwell's first pile, known as Gleep, started producing radio-isotopes in September 1947, reaching its peak output with about 150 specimens a month. The second pile, Bepo, was first used to produce radio-elements in February 1949, and its output is sufficient not only to meet all the British needs but to leave a surplus for export.

Tracing a Trace Element

Radioactive cobalt has been in the news because it appears to be the best of the radio-elements from the point of view of possible substitution for radium in therapy. Radio-cobalt is also being used as a tracer by scientists interested in discovering what happens to cobalt inside the body of animals, a study of considerable economic importance since the absence of cobalt from pasture causes serious deficiency diseases among sheep and cattle. In an announcement made last month by the head of the Isotopes Division of the U.S. Atomic Energy Commission, Dr. Paul C. Aebersold, stressed the need for more knowledge about the cobalt economy of animals, citing the fact that cows fed on forage containing less than four parts of cobalt in one hundred million, he said, lose their appetites and literally starve to death, although the pasture around them may appear luxuriant. He said that areas of serious cobalt deficiency—and so troubled by livestock malnutrition—have turned up in Florida, Michigan, Massachusetts, Wisconsin, New Hampshire and North Carolina, Dr. Aebersold said. Radio-cobalt tests, still in the early stages, have shown that cobalt is required in bacterial processes of digestion in the rumen, or first stomach, of both cows and sheep.

Almost simultaneously came a statement from the Minister in charge of New Zealand's Department of Scientific and Industrial Research that radio-cobalt is proving most helpful to the N.Z. Department of Agriculture in its experiments on the cause and cure of bush-sickness, a cobalt-deficiency disease of sheep. New Zealand, he said, was relying mainly on radioactive isotopes flown from America.

Dumping Ground for Atomic Waste

Harwell has enlisted the aid of the Navy to ensure disposal, with the maximum degree of safety, of radio-active waste, which presents almost the most awkward problem to which the running of atomic piles has given rise. Last month a special road convoy transported twenty sealed drums of such waste to a port where they were loaded on to a destroyer. The ship took them far out into the Atlantic, and sunk them at a spot where the ocean is 12,000 feet deep. It was stated that the small amount of radio-active waste that was dumped would not constitute a danger to fish life in the area.

U.S. Industry and Atomic Energy

After studying a report by an industrial advisory group recommending that U.S. industry should play a greater part in atomic energy development, David Lilienthal (chairman of the Atomic Energy Commission) said the recommendations seemed practicable. Meanwhile, he pointed out, important developments have occurred recently along the lines recommended in the report, with the entry of two U.S. industrial leaders into key parts of the atomic energy programme.

1. The undertaking of a complete survey of chemical process problems involved in plutonium production by E. I. duPont de Nemours and Company.

General Electric, Kellex, Monsanto and Standard Oil, he added, were already working on phases of the matter.

2. Undertaking the construction of experimental atomic reactors for eventual use as engines for driving ships, by the Westinghouse Electric Corporation.

British Association Meeting: August 31–September 7

The preliminary programme for the British Association's annual meeting at Newcastle (August 31–September 7) is now ready and a copy can be obtained on application to the B.A., Burlington House, Piccadilly, London, W.1.

The presidential address to be delivered by Sir John Russell at the City Hall on the evening of August 31, will discuss "World Food and World Population". This subject also provides the theme for a public symposium arranged by the Association's Division for Social and International Relations of Science on the evening of September 3, in which Sir John Russell, Lord Orr, Lord Horden, and representatives of F.A.O. and Unesco are expected to take part.

Two popular lectures are being given as usual, one of them by Professor Pettersson, leader of the recent Swedish Deep-sea Expedition, who is also going to read a paper to the Geology section.

Several sessions are being devoted to subjects of particular typical interest, including ultrasonics, the new compounds of fluorine and the artificial production of mutations.

The Newcastle neighbourhood holds great interest not only scientifically, for field biologists and geologists, but also technologically, and a most varied range of visits has been arranged to local shipyards, mines, chemical factories and the like.

Safety in Chemical Laboratories

Many accidents that occur in chemical laboratories would be avoidable if experimenters, particularly juvenile experimenters, were forewarned. A booklet has just appeared which gives many useful hints about possible hazards and how to avoid them. *Safety Measures in Chemical Laboratories*, published for the D.S.I.R. by H.M.S.O., price 6*d.* (post 7*d.*), covers the main causes of personal injury and material damage. The booklet was originally designed for the guidance of new staff at the Chemical Research Laboratory, but after it has been prepared for internal use it was considered that it might be of value in a wider field.

The booklet contains sections on general laboratory operations and the use of apparatus, fire risks and burns, dermatitis, electrical hazards and shock, poisons, poison gases and the treatment of affected persons.

Jenner's Centenary

May 17 is the bicentenary of the birth of Edward Jenner, M.D., F.R.S., who established the technique of vaccination against smallpox. It was on May 14, 1796, that he performed the first vaccination—inoculating a boy named James Phipps with lymph taken from a cowpox vesicle on a milkmaid's hand. Thereafter, in propagating the gospel of vaccination he "spent much of his private income, and . . . sacrificed professional advantages" (says one of his biographies), and it was only fitting that eventually the Government made him a grant of £10,000 for his historic discovery.

Jenner was also a first-class naturalist, and it was his painstaking observations which disclosed the extraordinary habits of the young cuckoo.

D.S.I.R. and Chemical Engineering

The Advisory Council of the D.S.I.R. is appointing a Committee under the chairmanship of Mr. H. W. Cremer to review the needs for research in the field of chemical engineering. The Committee's terms of reference will be:

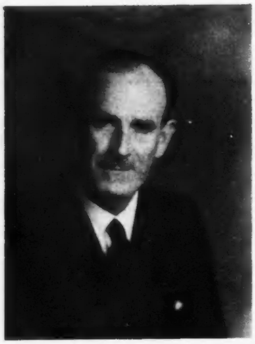
To review the needs for research in chemical engineering and the extent to which they can be met by existing research establishments.

Preventing Air-sickness

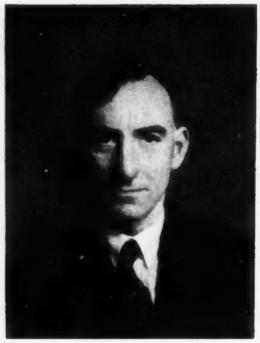
Best preventive measure against air-sickness is a dose of hyoscine hydrobromide swallowed about an hour before flight, and repeated two hours later, state the medical experts of British Overseas Airways and British South American Airways Corporations in an article in *British Medical Journal* (April 9, 1949). In a footnote they refer to another drug, Dramamine, which the U.S. Army Medical Department claim to be more efficient than hyoscine.

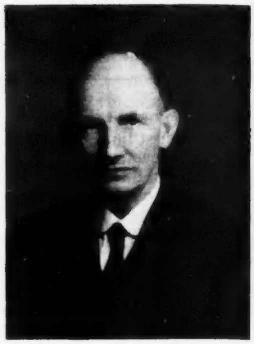
Unesco Book-token Scheme

Unesco announces that its Book-token Scheme (described in Discovery, January 1949, p. 6) is proving such a success that when the present experimental period ends this year the initial 150,000 dollars with which the scheme was launched last December is to be increased to 250,000 dollars. It is also hoped to find other


Prof. MEIRION THOMAS


Prof. J. F. ALLEN


Prof. J. M. WHITTAKER


Dr. U. R. EVANS

sources of 'hard' currency so that the scheme can be extended still further.

The object of the scheme is to enable organisations and individuals in 'soft' currency areas to purchase non-fiction publications from 'hard' currency areas. Switzerland has just agreed to participate in the scheme as a book-selling country. This brings the number of book-selling countries to five, the others being the United Kingdom, the United States, France and Czechoslovakia.

The scheme has been a particular success in France where 20,000 dollars' worth of coupons was nearly exhausted three weeks after it had started. Its reception in Britain has been very different, for demands for the 20,000 dollars' worth of coupons available have so far been very small, but they are beginning to grow. Only a little over 1000 dollars' worth of coupons have been used by thirty-two organisations, booksellers or individuals. If within the next few months the sale of coupons in this country continues to be small, Unesco may decide to re-allocate these coupons to other countries where the demand is greater. Applications for book coupons in this country should be made without delay to Unesco Book Coupons, c/o Book Tokens Ltd., 28 Little Russell Street, London, W.C.1.

More Nitrogen, More Grass

THE outstanding recommendation in the first report of the Government's Committee on Industrial Productivity (Stationery Office, Cmd. 7665, 6*d.*) is concerned with agricultural production, and extrapolates from the pointed warning which Professor G. Scott Robertson gave in his presidential address to the Agricultural Section of last year's British Association —"*All the science of nutrition cannot replace grass.*"

The Committee on Industrial Productivity advocates greater reliance on grass as a feeding stuff, and less on imported cattle foods. The nutrient value of an acre of grass can be increased two or three times by good management, and it should be possible to obtain with the next four years a 20% increase in the total yield of Britain's grassland. This would be equivalent to an annual import of feeding stuffs of £40 million. Such an increased output from grassland would necessitate extra supplies of nitrogenous fertilisers (which at present are applied to only about a quarter of Britain's pasture land). The Committee recommends that urgent consideration be given to the provision of substantially more capacity for producing these fertilisers. Meanwhile the Committee's Imports Substitution Panel is continuing its study of the most suitable forms in which nitrogenous fertilisers might be produced.

The Committee also recommends that intensive war should be waged against rabbits which consume at least seven million tons of grass each year.

Supersonic Planes

A SWEPT-BACK wing jet fighter intended for the investigation of flight problems at and beyond the speed of sound is in production in Britain. This plane, the Supermarine 510, made by Vickers-Armstrong, was announced last month. It is a development of the Attacker which set up a record for the 100-kilometre closed circuit at the beginning of 1948 with a speed of 564·88 m.p.h., later beaten by the de Havilland 108.

From the U.S.A. it is reported that the research rocket plane, known as the X-1, has flown 'hundreds of miles' faster than sound, and according to one account "has probably flown above Mach 2 (1324 m.p.h.) and reached a height above 60,000 feet."

Chemical Tests for Cancer

A TEAM of American researchers working at Chicago University have devised a chemical test which shows, it is claimed, whether or not the donor of a blood sample is suffering from cancer. This was announced at the recent Detroit meeting of the American Association for cancer research by Dr. Charles B. Huggins, who worked out the new technique in collaboration with Dr. Elwood V. Jensen and Gerald V. Miller.

The principle of the test is as follows. Iodoacetate is added to the blood sample which is then heated, and the heating process causes coagulation of the serum albumin. If the blood comes from a cancer sufferer then the albumin coagulates more readily than happens with blood from a normal healthy person. The same ready coagulation does occur in the case of tuberculosis and certain other diseases, but these diseases are all ones that are readily distinguishable from cancer by other means.

The test has been tried on a random sample of 300 people, and proved positive for all cancer cases.

Hybrid Corn in Italy

HYBRID corn (maize) from America is now being tried extensively in Italy, where it is proving very successful. One test sowing at Mantua raised the yield from 1·6 tons an acre to 2·8, and another test showed an increase from 1·7 to 3·2 tons.

Zoo Attendance near Record

ATTENDANCE at the London Zoo last year amounted to 2,335,539—the second highest figure ever reached, and 357,042 people visited Whipsnade.

Liquid Paraffin: Warning to Housewives

THE use of mineral oils in the manufacture of foods was forbidden last month by the Ministry of Food. The Ministry's statement, which was issued in explanation of the order, stressed the fact that mineral oils, such as 'liquid paraffin', are without nutritional value and may even have harmful effects. Housewives were urged not to use them as substitutes for edible oils in cooking. Although medicinal paraffin may safely be so used under medical supervision, its regular consumption may lead to deposits of the oil in certain organs of the body. Paraffin, whether medicinal or not, dissolves vitamin A (and its precursor carotene) and vitamin D, and inhibits the assimilation of these essential vitamins by the digestive system. Experiments have shown that as much as 50% of vitamin A and carotene may be lost in this way when liquid paraffin is substituted for fat in the diets of laboratory animals.

Readers will recall that the medical press has published evidence which suggests that cancer-producing substances may be produced when mineral oils are heated to the temperatures encountered in cooking.

'Albatross' Expedition wins Medal for Leader

PROFESSOR HANS PETTERSSON, who led the *Albatross* deep-sea expedition to which we devoted much space in our November 1948 issue, has been awarded the Patron's Medal of the Royal Geographical Society. This award was given to Professor Pettersson specifically for his leadership of the

New F.R.S.'s

Prof. KENNETH MATHER

N. W. PIRIE

Prof. P. B. MEDAWAR

Albatross expedition, in which (continues the citation) much new evidence has been obtained of the geology of the ocean floor.

The Physical Society Exhibition

THE Physical Society's thirty-third Exhibition of Scientific Instruments provided no strikingly new devices but plenty of evidence of improvements in the design of standard instruments. As on previous occasions it is possible to pick out a few instruments which stood out from the rest as having fully emerged from the chrysalis stage. This year it was the turn of the D.C. Amplifier, an instrument for amplifying very small direct currents—of the order of one hundred thousand millionth of an ampere—so that they can be measured or made to actuate other mechanisms. Various types were in evidence, but the most popular was the *magnetic amplifier*. The applications of the instrument are numerous, but one which is likely to gain in importance is the *electrical strain gauge*, with which the small movements accompanying strain in metal structures under various load conditions can be measured by recording the changes in resistance of their wires glued to the surfaces.

Elaborate electronic devices again occupied much space. Amongst these was an ingenious electronic watch-timer made by Dawe Instruments Ltd.

Several electronic calculating machines were exhibited, based on the principles employed in the giant ENIAC machines, considerably smaller in size. One of these, carrying the delightful appropriate name of 'SESAME' was described as a simultaneous equation solver and matrix evaluator.

The exhibits sponsored by the various service and government laboratories made an impressive collection. They included an excellent and simple mass spectrometer constructed mainly from standard service electronic units, a rescue light for submarine survivors which uses sea-water as the electrolyte of its battery and lights up on immersion, an electrical model for solving problems connected with the insulation and heating of buildings, and a demonstration of the tensions set up in metals on impact which showed how a shell which might pierce thick armour plate would itself be shattered on striking thinner armour.

In spite of the absence of many really novel advances the vitality of this industry, which now exports to the value of £10 million a year in place of its pre-war £2 million, was well demonstrated by this year's exhibition.

Selective Weed-killer for Lawns

AMONG the synthetic growth regulators mentioned in our recent note "Calling all Gardeners" (February 1949, pp. 33–35) was 2,4-D, also known in Britain as DCPA. An entirely new ester formulation of 2,4-D type—called DICOTOX—has now been put on the market by May and Baker Ltd., of Dagenham, Essex. It is designed for use in connexion with lawns.

Every gardener is familiar with the difficulties, when sowing a new lawn, of eradicating by hand the dormant weeds which will sprout before the new seedling grasses are established. An application of Dicotox may be safely used for the destruction of weed seedlings immediately prior to sowing grass seed. It does not inhibit germination of the grass seed and will give the new lawn a good start. In an established lawn, a single treatment of this weed-killer normally confers freedom from susceptible weeds for at least one season. Supplies are at present only sufficient for the United Kingdom, but the manufacturers hope to make the product available in certain overseas markets in the near future.

The Toxicity of DDT

IN some respects the new synthetic insecticides are too efficient if judged by their effects on the balance of organisms in a particular animal population; there is, for instance, the now well-known effect where DDT is used which ends up with the red spider becoming a serious pest after it has bred rapidly and filled the biological vacuum created when the insecticides killed off the insect pests. Moreover, the toxicity of DDT has to be taken into account where it is used in such places as cow-sheds; in the U.S.A., for instance, dairy farmers have been warned to take care when spraying cow-sheds with DDT as the insecticide could contaminate the milk and make it poisonous.

There has been some concern, too, among fruit farmers, who have feared that the use of sprays containing DDT might render the fruit poisonous. Experiments carried out at the University of California Citrus Experiment Station indicate that there is little danger in the case of oranges, lemons and grapefruits, though a small proportion of DDT (17 to 23 parts per million) is to be found in the *peel* of citrus fruits six months after ordinary spraying.

A paper presented to the American Chemical Society on March 30 states that neither DDT nor parathion (another potent synthetic insecticide) has been found in the pulp of apples, pears, peaches or plums after treatment with standard dosages of these insecticides. Olives were found to contain about 12 parts per million of DDT.

Considerable attention has been given to the feasibility of removing traces of DDT and parathion remaining on the surface of sprayed fruits without injuring the fruits involved. Sodium silicate has proved best in ridding apples and pears of surface DDT, effecting a removal as of much as 90% and an alkaline soap has worked well with oranges.

Catalogue of Engineering Books

THE scientific and technical booksellers, H. K. Lewis & Co. Ltd., are producing a series of catalogues in which are listed books dealing with various special branches of science and technology. The latest addition to the series is a catalogue of books on civil and mechanical engineering and industrial organisation, and is available on application to Lewis's, 136 Gower Street, London, W.C.1.

Lysenko gets a Stalin Prize

AMONG the Stalin Prize-winners announced for 1948 is TROFIM LYSENKO, who has been given a First Prize (200,000 roubles). According to *Soviet News* he gained the award "for scientific research in the sphere of advanced Michurin Biological Sciences summarised in *Agrobiology*."

Unesco and Popular Sciences

MAURICE GOLDSMITH, science correspondent of *Reynolds News* and secretary of the Association of British Science Writers, has joined Unesco as programme assistant in the office concerned with the popularisation of science.

New Publishers for "Frontiers of Science"

CHAPMAN & HALL LTD. announce that they have acquired from Pilot Press Ltd. their complete list of scientific and technical books, including the well-known

"Frontiers of Science" series, which will be continued in its present form with further additions. All inquiries for these books should be addressed in future to Chapman & Hall Ltd., 37 Essex Street, Strand, London, W.C.2, or to Book Centre Ltd., North Circular Road, Neasden, N.W.10.

Strains for Microscopists

A USEFUL catalogue of microscopical strains and reagents, together with descriptions of the best methods of using them, has been prepared by British Drug Houses Ltd., and can be obtained free on application to the firm's Laboratory Chemicals Group at Poole, Dorset.

Britain's Hunt for Uranium

AN effort to stimulate interest among Colonial mining houses and prospectors in locating substantial deposits of uranium and thorium is being made by the British Ministry of Supply, and an announcement is being published in all Colonial territories where there is considered to be a possibility of locating the radioactive materials. The effort is particularly directed to Colonial territories, as it is considered that the chances of important deposits being discovered there are greater than in Britain, which has already been surveyed more completely than any other part of the world. Colonial Geological Surveys, and also the Geological Survey of Great Britain, are giving advice and analysing samples brought in by prospectors; and Geiger-Muller counters produced in Britain are being used and made available for sale in increasing numbers in the Colonies. The search for radioactive minerals in the self-governing countries of the Commonwealth is already being actively pursued by the respective Governments.

According to the official announcement issued in the Colonies, the British Ministry of Supply offers to buy all uranium ores and concentrates produced in the Colonial Empire during the next ten years at a minimum price of 13*s*. 9*d*. per lb. of contained uranium oxide. This offer is subject only to the reservations that the Ministry does not *guarantee* to purchase ore or concentrate containing less than 10% uranium oxide, nor does it guarantee to purchase lots of less than 10 tons ore or concentrate.

The Ministry will take into account the presence of other valuable constituents of the ore having regard to the cost of recovery. Where the concentrates potentially available from a deposit are adequate to justify the outlay, the Ministry would be willing to provide the capital required for the installation of concentrating plants.

No specific offer is made for thorium-containing minerals, but the Ministry states that it is very ready to discuss terms for purchase from any would-be vendor of thorium minerals.

Death of Synthetic Petrol Pioneer

DR. FRIEDRICH KARL RUDOLPH BERGIUS, whose process for manufacturing synthetic petroleum was as vital to Germany in World War II as the Haken process was in World War I, died in Buenos Aires on March 31. He was sixty-five.

Bergius, whose process must certainly rank as one of the very greatest feats of chemical synthesis seen this century, was born on October 11, 1884, in Goldschmieden in Silesia. His father was president of the Goldschmieden Chemical Works. His scientific training was gained at the universities of Breslau, Leipzig (where he studied under Hantzsch and Abegg, and gained his Dr.Phil. in 1907), Berlin (where he worked under Nernst) and Karlsruhe (under Haber). In 1909 he became a lecturer in Hanover's Technical College, where he installed a laboratory of his own in order to study the influence of high pressures on chemical reactions. Out of this early work came the germ of the idea which he was to carry through to its logical industrial conclusion, the production of motor spirit by the hydrogenation, under high pressure, of coal. In 1913 he transferred his researches to the Coal Research Laboratories of Th. Goldschmidt A.G. at Essen. Three years later these laboratories were moved to Mannheim-Rheinau, and by that time he had developed his process of coal liquefaction to the stage when a pilot plant could be built and the process tested on a semi-commercial scale; the data collected from which the operation of that plant made it possible to design the first full-scale plant.

Dr. FRIEDRICH BERGIUS

Bergius saw his ambition realised in 1927 when I.G. Farbenindustrie built its first plant to produce synthetic petrol by the Bergius process; this was the Leuna Works near Merseburg, one measure of whose importance was high position on the list of targets prepared by the Britain's Ministry of Economic Warfare in World War II. Britain and America have both exploited the Bergius Process. It is interesting to note that the original tests of the suitability of British coals by hydrogenation were carried out under Bergius's direction at Mannheim-Rheinau, and afterwards further experiments were made by the Fuel Research Station at Greenwich under an agreement signed by the Department of Scientific and Industrial Research, the British Bergius Syndicate (which held the patent rights in the Bergius Process for the whole of the British Empire) and Dr. Bergius. Under this arrangement, it should be noted, full details of the process were placed at the disposal of our Government, which was enabled to build a plant incorporating all the latest technical improvements at the Fuel Research Station. This plant was installed in 1926 and was operating the following year, when the small scale experiments that had been started at Mannheim-Rheinau on behalf of the British Government were discontinued. The Fuel Research Station published a great deal of work on the Bergius process —notably in *Technical Papers* Nos. 29 (1931), 42 (1935) and 44 (1938).

Another important process developed by Bergius makes it possible to hydrolise wood to sugar and then convert that sugar into cattle feed. (The underlying principle was not, of course, original: credit for the initial research on this hydrolysis goes to Willstätter.) The process was brought into large-scale production in Germany during World War II, and is now reported to be in operation in the United States.

In 1931 Bergius shared the Nobel Prize for Chemistry with Carl Bosch for his "services regarding the invention and development of chemical high-pressure methods". Among his many other honours he held the Liebig and Melchett medals.

Scientific Liaison with France

THE Department of Scientific and Industrial Research has appointed Mr. A. H. Waterfield for scientific liaison duties in France, with the rank of Attache at H.M. Embassy in Paris. Mr. Waterfield, who is a metallurgist with special experience in the light alloy field, was formerly on the Headquarters Staff of the Ministry of Aircraft Production, later the Ministry of Supply. In 1946–47 he was attached to the U.K. Scientific Mission in Washington for metallurgical liaison duties.

As Scientific Attache in Paris his responsibilities will include helping U.K. Departments on various matters of fundamental and applied science and technology in France, especially in the fields of interest to D.S.I.R. and the industrial Research Associations.

Hydraulics Research Organisation

THE Director of Hydraulics Research, Sir Claude Inglis, and the London office of the Hydraulics Research Organisation, has moved from Victoria Street to:

Rex House, 4-12 Regent Street, London, S.W.1 (*Telephone number:* Whitehall 9788 Ext. 16).

Acknowledgment

DR. GEOFFREY H. BOURNE asks us to express his thanks to Professor W. E. LE GROS CLARK for permission to reproduce the two photomicrographs which illustrated his article "Tasting and Smelling" (March 1949, pp. 93–97).

The Bookshelf

Human Evolution. By Sir Arthur Keith, (London, Watts, 1948; pp. 451, 21*s*.)

In his retirement the doyen of anthropology has summed up his ideas on the evolution of the human race. In doing this he propounds what he terms 'a new theory of human evolution'. Briefly, Keith holds that the formation of the social group was a pre-requisite of human evolution and that the development of man was only possible, and is still only possible, through the evolution which occurs when such groups were and are separated by geographical or nationalistic barriers. There must be the development of social life and the social unit thus formed must in some way be segregated and integrated and group symbols and group recognition developed, before racial evolution takes place.

The evolution of the human species as a whole depends on the evolution of its separate races and ethnic groups. Keith claims that such evolution demands the development of nationalism or some other form of racial or ethnic segregation, although this segregation may be broken down in the later stages.

He also compares the lengthening of the gestation period in man over that found in the chimpanzee—a factor which is correlated with the development of hairlessness and greater mental development in man—with the increase in 'childhood' due to the development of civilisation which, in a similar fashion, leads—in his opinion—to an increase in the potentiality of mental development.

The book is written in a fluent and easily readable style and contains a vast amount of material concerning the behaviour of many tribes, races and nations, past and present.

For this reason alone it is worth reading, even if the thesis which led to its being written prove unacceptable. But it is doubtful if many people, Aryan or Semitic, will find Keith's long analysis of the Jewish problem in the later chapters either just, accurate or acceptable.

Animal Encyclopaedia: Mammals. By Leo Wender. English edition, edited by M. A. C. Hinton. (London, Allen & Unwin, 1948; pp. 266, 12*s*. 6*d*.)

It is a pleasure to be able to agree for once with the blurb on the dust cover of a book, for this volume is just what the publishers claim it to be, "a complete dictionary of mammals containing the essential facts about the habits and characteristics of every known mammal in all its varieties." More than 1500 forms are described and the book will provide the quickest answer to nearly every question the non-specialist is likely to ask about mammals. It can be particularly recommended to anyone who has any contact with the kind of child whose curiosity is aroused rather than satisfied by a visit to a zoo, and most children come into that category. Leo Wender, who spent ten years on the job, did a wonderful piece of compilation, to which the English editor has added more than an editor's fair share.

Among the appendices is a comprehensive classification of mammals, and an index which gives you the English name for a species if you know the Latin one. There is also a table giving the gestation periods and the number of young normally born to various species of mammals; the elephant, of course, holds the 'gestation record' with 18 to 24 months, but readers may be surprised at the runners-up —the giraffe (400 to 481 days), the zebra (346 to 395 days) and the bactrian camel (343 to 390 days). Another snippet of information is given which is absent from many standard natural histories: the gestation period for the Large Kangaroo is 39 days, after which the little 'joeys' spend a further 180 days in the mother's pouch. Altogether, this is a very handy reference book for anyone interested in mammals.

Physical Aspects of Colour. By P. J. Bouma. (Philips Technical Library, Cleaver-Hume Press, London, 1948, pp. 272 inc., 27*s*.)

Textbooks on colour have in the past suffered from a tendency towards the doctrinaire—they have even, on occasions, been the medium for personal vendettas. No such charge could be brought against this book. Although the theoretical sympathies of the author are not disguised he has kept his feet firmly on the ground of physical experiment. The experimental basis of the science of colour measurement is discussed at length and this forms the main body of the work. The treatment throughout this section differs in many ways from that followed in British and American texts, being closer to the continental tradition of Schrödinger and Helmholtz. In a subject in which many concepts are notoriously difficult to grasp a fresh approach is often all that is necessary to turn blank incomprehension into astonished understanding, and for this reason the book is a welcome addition to the English literature. Other topics dealt with include the characteristics and heredity of defective colour vision, and the measurement of the sensitivity of the normal eye to small colour differences. There is also an interesting chapter on the historical development of colour science.

C. G. A. H.

Pioneers of Fertility. By Crichton Porteous; illustrated by Michael Ayrton. (London, Fertiliser Journal Ltd., 1949; pp. 125, 10*s*.)

This book contains 22 short biographies of men who have made significant contributions to the increase of agricultural productivity. The scientists who come into the volume include Sir Humphry Davy, Liebig, Lawes and Gilbert (founders of the Rothamsted Experimental Station), Dr. Voelcker and Dr. Robert Warington. The biographical approach will hold a special appeal for the layman for whom the book appears to be intended primarily, and it should also interest a great many schoolchildren.

Atmospheric Electricity. By J. Alan Chalmers. (Oxford University Press, 1949; pp. 175, 15*s*.)

This monograph, written by a recognised authority on the subject of atmospheric electricity, fills a gap which has existed in the English literature far too long. It deals with the movement of ions in the atmosphere, air-earth currents in undisturbed and stormy weather, the maintenance of the earth's electric field, the thunder cloud, and the lightning discharge, and it is written in a clear concise style. Although it is primarily addressed to specialised workers in physics and meteorology, it would have proved even more useful to the general reader if wider use had been made of illustrations, in particular in connexion with specialised methods of measurement.

R. H. Golde

Carl Alsberg: Scientist at Large. A collection of essays edited by Joseph S. Davis. (Stanford University Press, 1948; London, Geoffrey Cumberlege, Oxford University Press, pp. 182, 11*s*. 6*d*.)

Great scientific administrators are as rare a species as great orchestral conductors. America has certainly produced its fair share of such men, the first and perhaps still the greatest of them all being Joseph Henry, the importance of whose role as an administrative scientist was so well brought out by J. G. Crowther in his *Famous American Men of Science*. A scientist in the true Henry tradition was Carl Alsberg, who died in 1940. He was in turn a research worker, establishing for himself a leading position among the younger biochemists by his investigations at Harvard, Woods-Hole and the U.S. Department of Agriculture; head of that department's Bureau of Chemistry, to which post he was appointed at the young age of thirty-five; one of the three directors of that remarkable organisation, the Food Research Institute of Stanford University, whose studies of food supply problems belong to the same *genre* as the recent fact-finding surveys of F.A.O. He began as a natural scientist, evolved into an administrator of exceptional calibre, and eventually entered the fields of social science and international relations; he introduced scientific method, for instance, into the affairs of the Institute of Pacific Relations (an institution with a purpose similar to that of our Royal Institute of International Affairs).

This book, written as a tribute to Alsberg's memory, deserves to be widely read on both sides of the Atlantic.

A few quotations selected at random will give the flavour of the book far better than any paraphrase or summary.

The following quotation comes from one of the two Alsberg lectures reprinted in this commemorative volume. Speaking of the principles of scientific administration he said: "One of them is that if you have five decisions to make at any given time, it is better to make them all with reasonable promptness than to stew over them for weeks and months. It is usually

better to make the decisions promptly even if some of them are wrong than to take a long time in order to avoid a mistake. Time is the essence of good administration. Inaction is the one thing people won't stand for. People will long endure bad government, but rebel almost instantly against a government that can't govern."

Again, to quote Alsberg himself: "Nothing sooner ruins *esprit de corps* than to have the head of an organisation take credit for the work of his subordinates. To push your assistants into the foreground is only a form of enlightened selfishness. That's why so many of my papers have been published under the joint authorship of myself and one or more assistants. We used to say in the Department of Agriculture that an assistant's name on a publication was worth more to the *esprit de corps* of the Department than a £500 raise in his salary. Another point to remember when you have subordinates whom you want to keep, men who are worth more than they are being paid, is to advance them in position or salary before they ask for it. This too is a form of enlightened selfishness. A £200-a-year raise which comes unsolicited before it is absolutely due is more effective than a £500 raise which the recipient has to wring out of you."

Alsberg always recognised that 'you cannot buy research'. To quote R. D. Calkins's comments on this point, Alsberg was motivated by this underlying conviction, considering that research "is a gamble, and it is safer to gamble on men than on projects. This view (Alsberg) urged relentlessly upon the philanthropic foundations financing and encouraging research. That research was a gamble he could attest by endless illustrations of how purposeful investigations and experiments had turned up highly unexpected results, and how some of the greatest discoveries came about by chance—chance in association with observant, imaginative men. A competent man with an original idea, he argued, could be encouraged and assisted, but a project and funds would not evoke originality. Nevertheless he was ready to admit that an organised research programme could, when properly staffed, make excellent if irregular progress on an entire front."

In these days when so many believe that the number of discoveries is in almost direct proportion to the number of millions of pounds spent on research, the lifetime experience of Alsberg, so well described in this book, should be an inducement to clearer thinking about scientific research and the administration of scientific establishments.

Egyptian Pyramids. By L. V. Grinsell. (John Bellows, Gloucester, 1947, 25*s.*)

THERE can be few people to whom "The Pyramids"—without further definition—do not immediately present a fairly clear mental image of the three famous monuments at Giza, so well shown in the air photograph on the jacket of this book. Taken together, as historically and archaeologically they have a right to be, they are the most spectacular achievement—in a period of three thousand years—of that continuous effort on the part of Egyptian royalty to solve two irreconcilable problems: the preservation of their memory *with* posterity, and of their bodies *from* it, in one and the same place.

No Pharaoh wholly succeeded in this ideal. The mummies of most of the great Imperial rulers, the Tuthmosides and the Ramessides, are safely and honourably housed in a single mausoleum in Cairo, but their corridor tombs, in the mountain across the water from Luxor, are open to the public. The Great Pyramid at Giza has ensured that the name of Cheops shall be known and admired by millions who will never see Egypt, but no one knows what has become of the body that was to have been protected by it for eternity. And though Tutankhamen's name has survived to be a household word in our day, and his mummy still lies in the tomb in which it was laid thirty-three centuries ago, his unique fortune is probably largely due to the fact that this was not the place he had prepared for his burial.

Long before his time the Pharaohs had given up, as unsuccessful, the pyramidal form of tomb. The form itself was retained on a smaller scale as a part of the private tomb for several centuries; and about 700 B.C. it was revived by the Ethiopian rulers of Egypt close to their capital at Napata in the Sudan, and subsequently it was adopted by the Meriotic Kings still farther up the Nile. There, at the end of the second century A.D., the Egyptian pyramid finally went out of fashion.

That is a far cry both in time and in architectural achievement from the Great Pyramid of Cheops. But the Giza pyramids, though in many ways the high-water mark in the development of the classic pyramid, represented only one stage in an almost continuous process which lasted for roughly a thousand years from the beginning of the Old Kingdom, about 2700 B.C. to the end of the Middle Kingdom.

With the exception of the two XIth dynasty examples at Thebes, all these pyramids were built on the edge of the desert, west of the Nile, strung out from the neighbourhood of Cairo to Il-lahun, a distance of less than 70 miles. They are all easily accessible, and the remains of at least a dozen of them are, in one way or another, as interesting, and sometimes as impressive as those at Giza. Architecturally, the whole series not only presents a fascinating study in the working out of a specialised solution of the twofold problem already mentioned, but is intimately connected with the rise of stone-working in Egypt, and has a central place in the development of Egyptian building. The pyramids are also of great importance for the understanding of Egyptian religion. Yet until the publication last year of Mr. I. E. S. Edwards's Pelican, *The Pyramids of Egypt*, no scholarly account of the whole subject was available. His book is already becoming a classic.

Now Mr. Grinsell has produced a more sumptuous, but much less reliable book on the same subject. An authority on the prehistoric barrows of this country, and of comparable burial remains in Europe generally, he was attracted to the study of the superficially similar monuments of Egypt when serving with the R.A.F. in Cairo during the recent war. Unfortunately he is not an Egyptologist, and though he has clearly spent a great deal of time and trouble on *ad hoc* research, both on the sites and in the literature, he is not adequately equipped, nor has he had the time, to digest the considerable material he has studied. His style is dull, and tends to an economy usually associated with guide books. His arrangement of his subject matter in two parts, the first consisting of five chapters on various "Aspects of Pyramid Study", the second "Topographical", which treats the pyramid fields in geographical order from north to south, has led to unnecessary repetition, and this in turn has increased the opportunity for inaccuracies and inconsistencies. But we must be grateful for some excellent and unusual photographs, especially those taken from the air.

S. R. K. GLANVILLE

Ancient Egyptian Materials and Industries. By A. Lucas. (Arnold, London, 1948; 3rd edn., pp. 570, 25*s.*)

THE author was for many years Hon. Consulting Chemist to the Department of Antiquities, Egypt, and spent some fifty years studying and analysing the materials used by the ancient Egyptians. Among his best-known work was the treatment of the relics from the tomb of Tutankhamen and the shaft of Hetepheres, and for some years before his death he was concerned in preserving the wall decorations in the tombs at Thebes, Saqqara, and elsewhere.

This book has stood alone in its particular field ever since the first edition appeared in 1926. The new edition has been largely rewritten, set in a smaller fount, and extended in length by some 120 pages over its predecessor which appeared in 1934.

The author's masterly exposition is characterised by the fullest documentation, the large number of his own analyses, and his just but critical use of the works of others. His method of recording chronologically the known occurrences of each substance is applied in each section. The attribution of many of the materials to their source of origin has amplified and given precision to our knowledge of foreign trade in ancient Egypt, notably in timber. The new material in the present edition includes three chapters on adhesives, beads, and inlaid eyes, but nearly all the other chapters have also been improved upon, especially those dealing with mummification and pottery, and a section on stone vessels has been added. New material in the chapter on building stones includes (p. 64) references to recently discovered stonework in tombs of Dynasty I, and to war-time discoveries in the Ma'sara Caves. The section on papyrus refers to the important finds of ropes of that material in the Tura Caves during the War (p. 161) and of an unused roll of papyrus in the Dynasty I tomb of Hemaka (p. 165).

This volume is not likely to be superseded for a very long time.

L. V. GRINSELL

Printed and Published in Great Britain by Jarrold & Sons, Ltd., Norwich. Editorial Offices: 244 High Holborn, W.C.1.

William Gossage's

name is generally associated with the mottled soap he patented in 1857. Not so well known, but far more important, were the "towers" which he invented in 1836 to absorb the hydrogen chloride evolved during the manufacture of alkali by the Leblanc process. This gas, liberated in increasing quantities as the industry expanded, caused great damage in the neighbourhood of alkali works. By converting it into hydrochloric acid, Gossage not only ended what was becoming a dangerous nuisance, but enabled an important mineral acid to be made cheaply and in enormous quantities from what had been regarded simply as industrial waste.

Born in Lincolnshire in 1799, William Gossage spent his youth assisting his uncle, a chemist and druggist in Chesterfield. He then went into business for himself in Leamington, but gave it up to start a salt and alkali works at Stoke Prior, Worcestershire. In 1850 he moved to Widnes, Lancashire, where he made soap as well as alkali. His inventive powers seemed inexhaustible. Starting in 1823, his patents followed each other in a continuous stream for over forty years. Nearly all were concerned with improvements in the manufacture of heavy chemicals, and some were far ahead of their time. For example, owing to engineering difficulties, his method of recovering the manganese dioxide used in making chlorine did not come into use until thirty years after he invented it. Gossage died at Bowdon, Cheshire, in 1877. His practical genius played a very important part in developing the British heavy chemical industry.

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